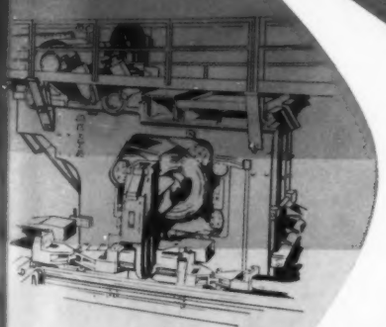
Iron and Steel ENGINEER

ENGINEERING SERVICE
TO THE IRON AND STEEL
INDUSTRY SINCE 1907

OCTOBER 1960



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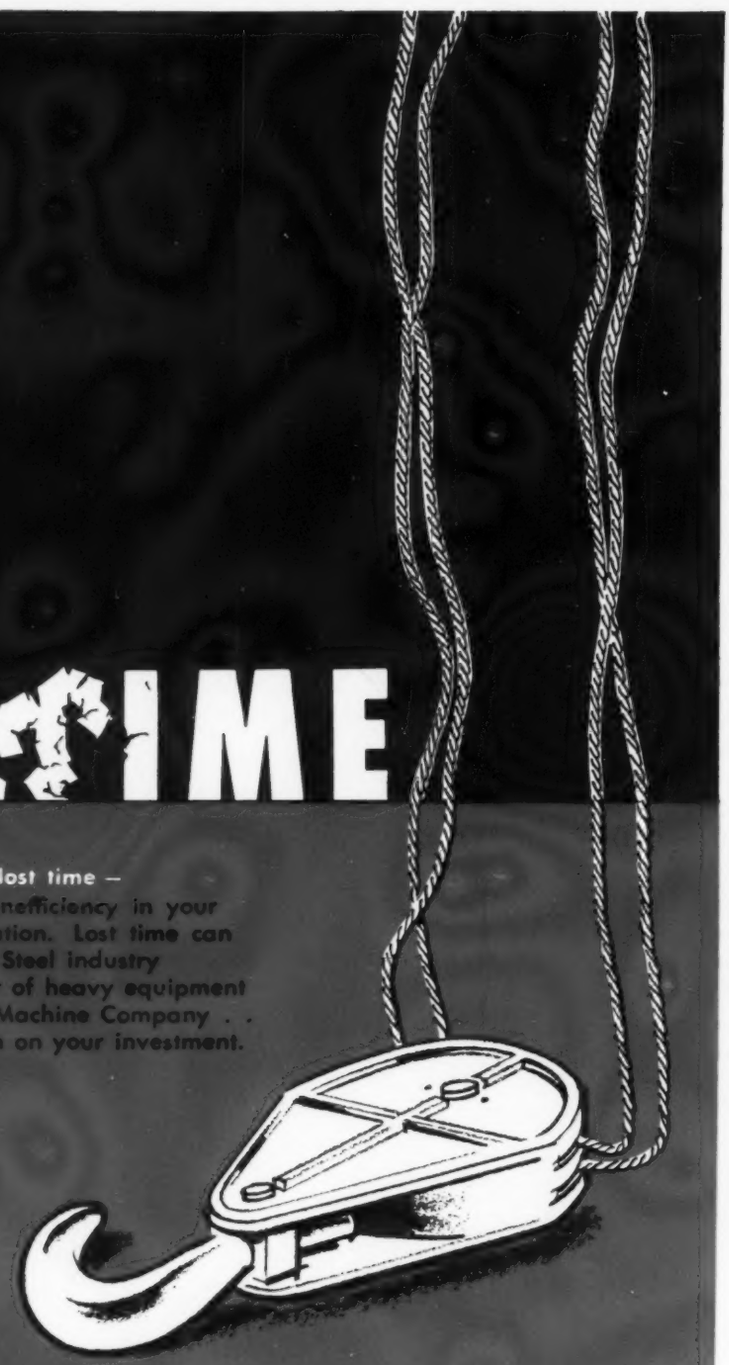
in your plant can mean lost time — expensive repairs, and inefficiency in your smooth production operation. Lost time can never be regained . . . Steel industry today looks to the leader of heavy equipment handling . . . Alliance Machine Company . . For greater overall return on your investment.



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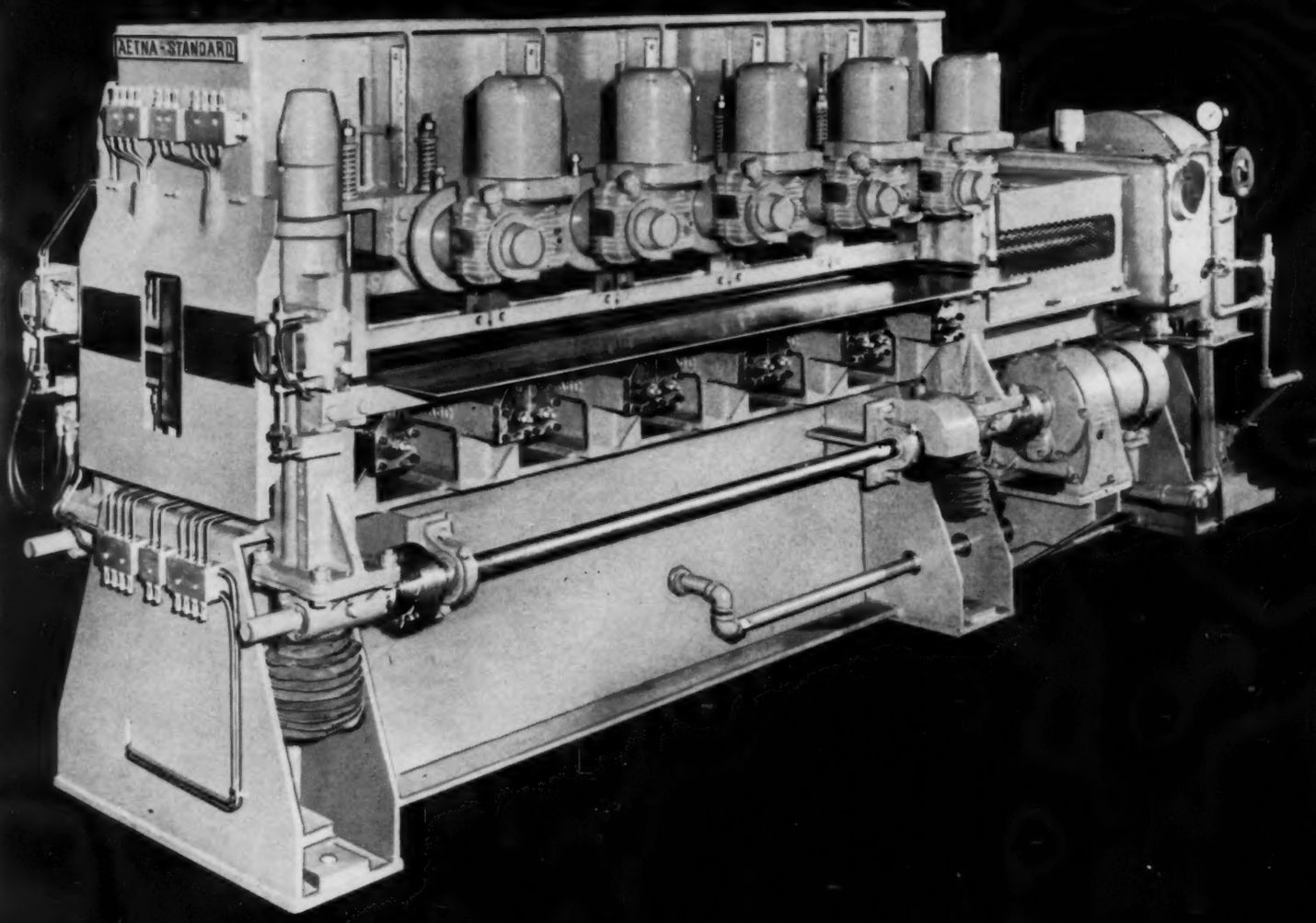
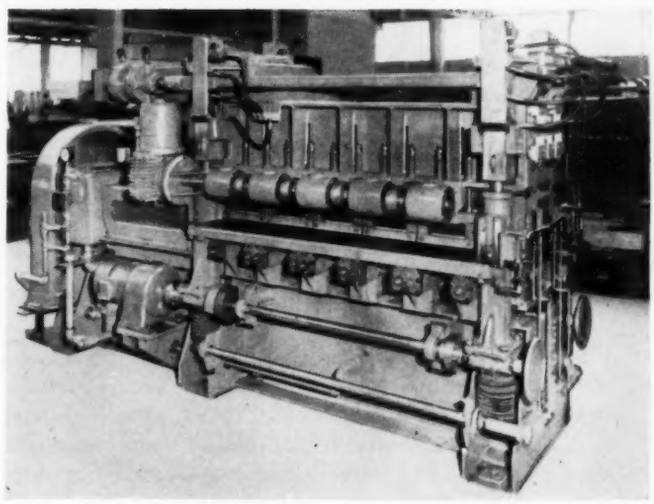


MORE WORK ON PRODUCT MADE POSSIBLE
WITH THIS
NEW ROLLER LEVELER

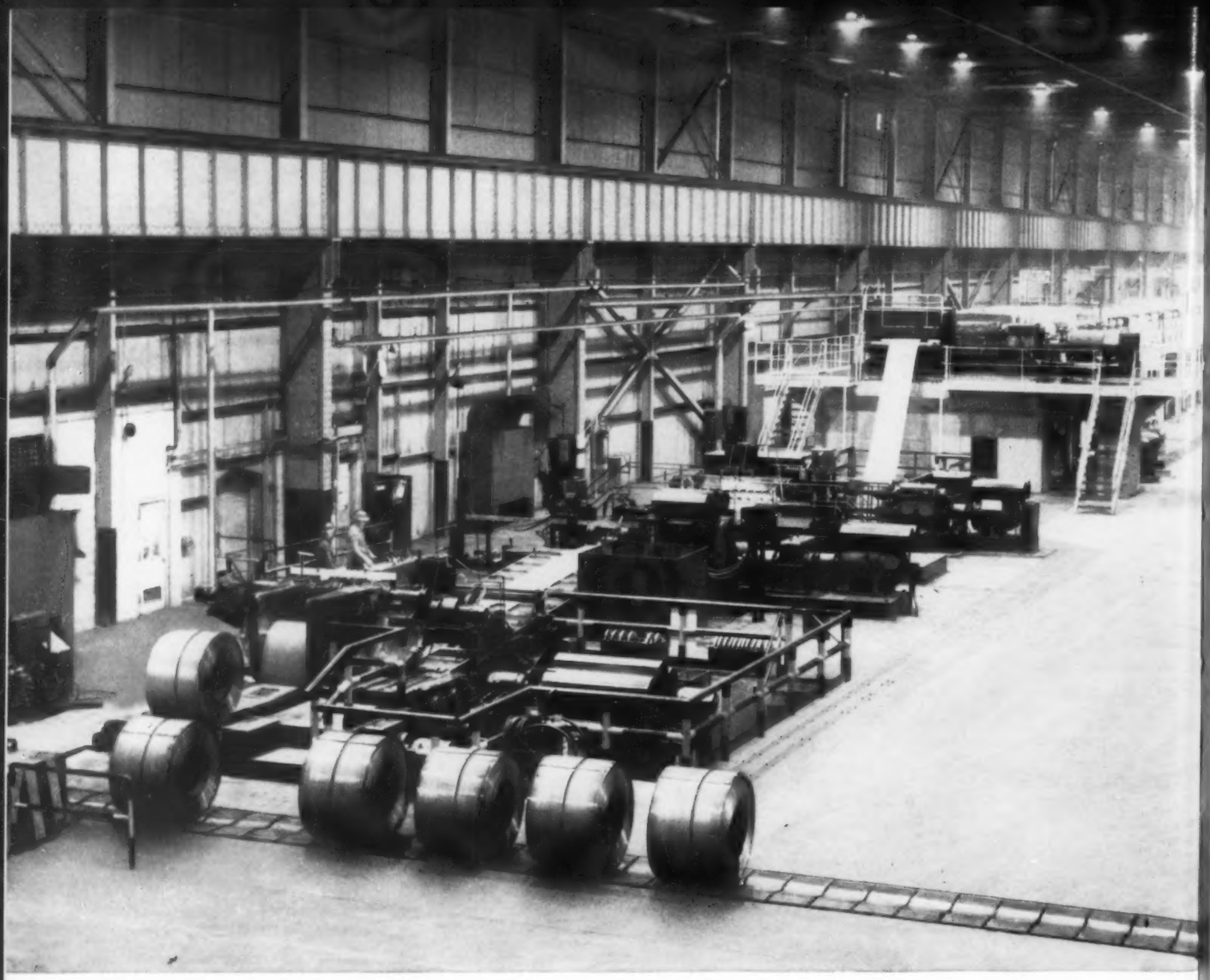
This new Roller Leveler, designed and manufactured by the Aetna-Standard Division of Blaw-Knox, has individual motor-operated back-up roll adjustments. The operator can easily make quick correction of product shape. The additional sets of back-up rolls make possible more flexibility of adjustment and more thorough working of the product. Motorized adjustments are also included for gauge thickness which make the unit fully equipped with power adjustments.

Leveler illustrated is 1¾" dia. x 72" face—21 rolls. Other sizes can be furnished to suit individual requirements. For detailed information on this new Roller Leveler or other Sheet and Strip Equipment, write: Aetna-Standard Division, Blaw-Knox Company, 300 Sixth Avenue, Pittsburgh 22, Pennsylvania.



AETNA-STANDARD MAKES MANY TYPES OF LEVELERS
These include 2 and 4 high Roller Levelers, Rectifier Levelers, Heavy Plate Levelers, Roller Levelers for tapered sheets.

Aetna-Standard Division
BLAW-KNOX



Gary adds fifth Wean Line to step up hot rolled strip pickling capacity

United States Steel Corporation recently installed this new Wean pickling line to give its Gary, Indiana plant increased capacity in its pickling department. The new line incorporates modern design features that make higher operating speeds possible without increasing the physical length of the pickling tanks.

This has been principally accomplished through the addition of a secondary scale breaking function, performed by a temper mill and two bridles. Another factor in increasing speed is the advance coil preparation station which trims end scrap before coils are fed into the line. In combination, the design improvements give the Gary No. 5 line entry speeds up to 2,000 fpm and pickling tank section speeds to 1,000 fpm. Entering coils of 62″ O.D. and 25,000 lbs. maximum can be built to 78″ O.D., 60,000 lb. coils.

This ultra-modern installation is one of the 85 pickle lines Wean has designed to serve the steel industry. It represents over 30 years of Wean's engineering experience in developing high-speed coil processing lines that serve every major American steel manufacturer—an unequalled background of "creative engineering" to serve you.

WEAN

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Iron AND Steel ENGINEER

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Published Monthly by

ASSOCIATION OF IRON AND STEEL ENGINEERS
1010 EMPIRE BUILDING PITTSBURGH 22, PENNSYLVANIA

Statements and opinions given in articles and papers appearing in "Iron and Steel Engineer" are the expressions of contributors, for which the Association of Iron and Steel Engineers assumes no responsibility.

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Indexed by Engineering Index and by Industrial Arts Index.

Single Copy Foreign Prepaid $2.00 (U. S. funds) Single Copy $1.50
Subscription price in U. S. and Canada (U. S. funds).....$ 7.50 per year
Subscription price in foreign countries (U. S. funds).....$10.00 per year

IRON AND STEEL ENGINEER: published monthly by Association of Iron and Steel Engineers at 20th and Northampton Sts., Easton, Pa. Editorial and advertising offices, 1010 Empire Bldg., Pittsburgh 22, Pa. Second-class mail privileges authorized at Easton, Pa. This publication is authorized to be mailed at the special rates of postage prescribed by Section 132.122.

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* ORIGINATORS AND LEADING PRODUCERS OF OPEN COIL AND SINGLE STACK FURNACES

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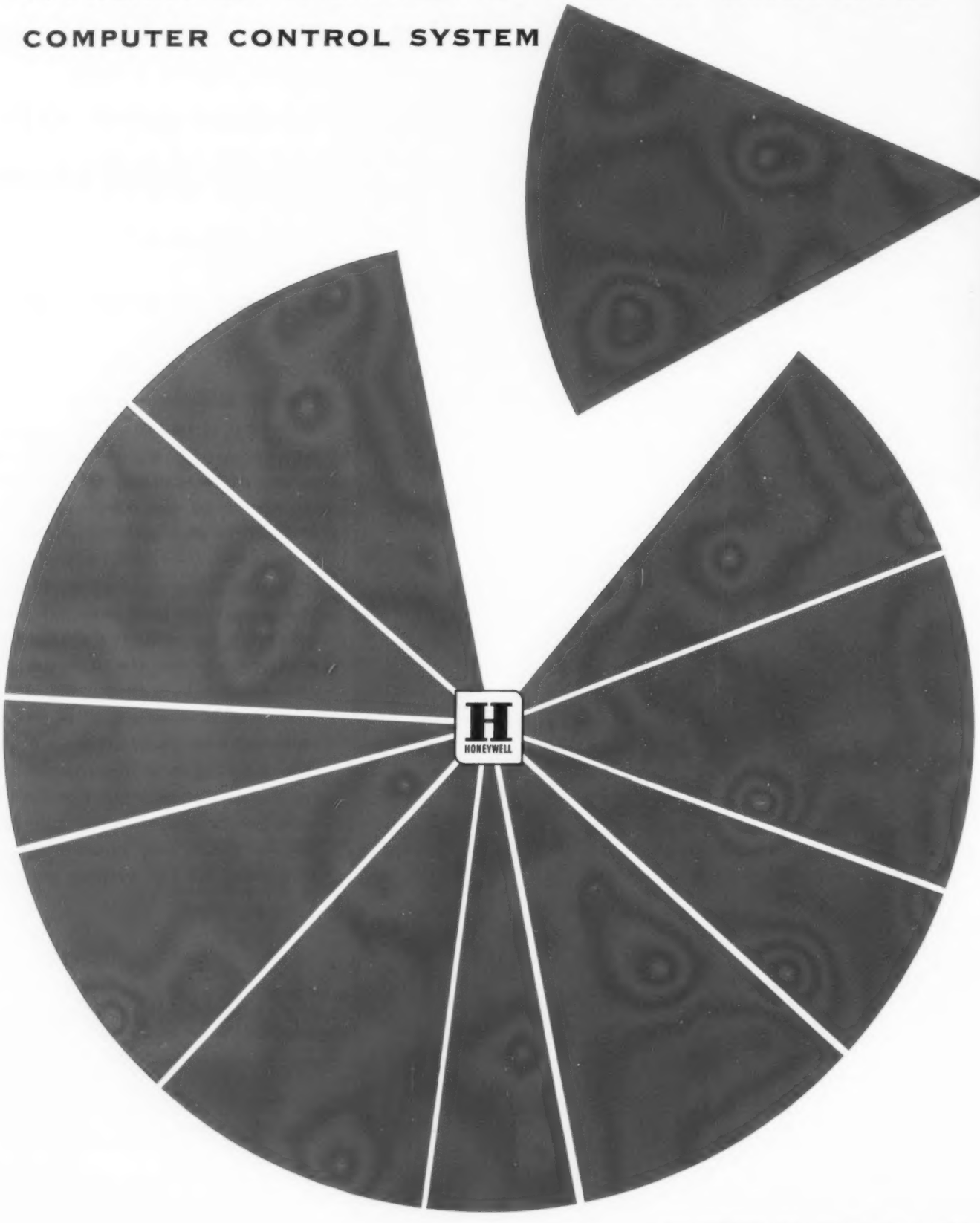

Single-Source Responsibility. Now you can get the first truly complete computer control package produced by a single manufacturer. The new, all-solid-state Honeywell 290 Industrial Digital Computer rounds out Honeywell's broad line of instrumentation, and enables you to specify an all-Honeywell process control system. That means you're protected by single-source responsibility . . . from primary elements to final controls, from initial concept through maintenance.

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First in Control

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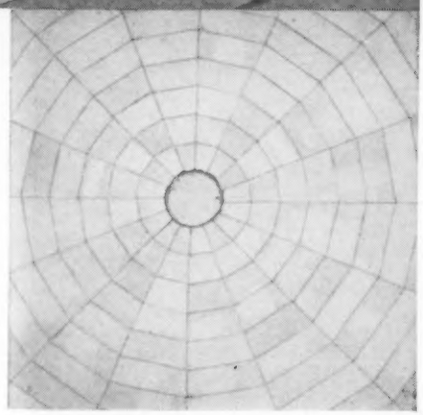
Bell-type annealing furnaces hold critical temperatures better—using J-M Superex

LEE WILSON ENGINEERING COMPANY, INC., STANDARDIZES ON J-M SUPEREX BLOCK INSULATION FOR PRECISION AND PERFORMANCE

In heat-treating furnaces, at temperatures to 1900F, Johns-Manville Superex® Block insulation provides greater efficiency and long operating life . . . because of its unique combination of low conductivity and low shrinkage at elevated temperatures. Control of critical processing temperatures is reached *and held* more easily.

Especially formulated from diatomaceous silica and asbestos, the large, strong, lightweight blocks of J-M Superex are cut with such careful precision that a furnace dome will support the weight of several workers during construction...*without any cement being used!*

This ideal combination of performance advantages and production skill is the reason Lee Wilson Engineering Co., Inc., employs J-M Superex for wall and dome insulation. It will pay you to insist on J-M Superex in your high-heat equipment. Write for details to Johns-Manville, Box 14, N. Y. 16, N. Y. In Canada: Port Credit, Ont. Cable: JOHNMANVIL.



Inside Looking Up ...*view from below the dome of a Lee Wilson bell-type furnace. Note close fitting between Superex blocks. This dome actually supports installation workers' weight* . . . without use of cement!

ONLY J-M SUPEREX BLOCK INSULATION GIVES YOU ALL THESE ADVANTAGES:

High Compressive Strength – only ⅛" compression under 85 lbs psi

Low Conductivity – .82 at 1000F mean temperature

Low Heat Shrinkage – 2.7% linear shrinkage at 1900F

Large Size Blocks – 12" x 36" blocks speed application, reduce number of joints. Yet blocks are light in weight for ease of installation

Lightweight – only 24 lbs per cubic foot

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AN INSULATION FOR EVERY COMMERCIAL AND INDUSTRIAL USE

JOHNS-MANVILLE JM PRODUCTS

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MODERN ALL-WELDED STEEL MILL CRANES

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OHIO

Crops *and* Shorts

△ In spite of austerity programs on the part of steel producers and allied industries, attendance at the 1960 Iron and Steel Exposition hit a record figure of 17,107, up 25 per cent over the Exposition of 1958.

Of the total, 12,369 were regular registered attendance and 3453 were from exhibiting companies. There were also 390 students, 836 women and 59 press representatives.

The Association of Iron and Steel Engineers appreciates the growing recognition and acceptance of its efforts. It is gratifying to hear the good comments stemming from the 1960 Exposition and Convention program. The Association thanks everyone who helped to make the affair so successful, and pledges to continue its activities for the benefit of the iron and steel industry.

Incidentally, the winner of the 1960 Thunderbird was A. J. Hall, Sprayon Products, Inc., Cleveland, Ohio.

△ A feature of the Exposition that attracted much interest was Allegheny-Ludlum's 1960 Thunderbird and its predecessor, the 1936 Ford, with stainless steel bodies. And both perform nicely on the road, even at speeds like tomorrow wasn't worth waiting for.

△ Some advance rumblings of what the United Steel Workers are thinking about: Improved pensions, retirement after 30 years service regardless of age, improved medical insurance, job protection against automation, better supplemental unemployment insurance, three-month vacations every five years after 20 years of service, no outside contracting. Shorter work hours were also mentioned but apparently will not show up for the time being.

△ Typifying the competition the United States steel industry faces, France in 1959 made 15,217,000 metric tons of steel as against 14,616,000 tons in 1958, an increase of 4.1 per cent. Total employment in 1959 was 160,500 as compared with 161,625 in 1958, a decrease of 0.7 per cent.

△ Another example of foreign expansion is Phoenix-Rheinrohr A.G., with 1,551,000 metric tons of ingots during the first half of the 1959–1960 fiscal year as against 1,022,000 metric tons for the same period of the 1958–59 fiscal year.

△ From *Puck:*

Efficiency experts—
At least those I've known—
Can cope with any troubles,
But not with their own.

△ A correspondent notes that parents are people who bear infants, bore teenagers and board newlyweds.

△ In the midst of all the campaign oratory, it is well to recall Mackenzie King's statement: "The politician's promises of yesterday are the taxes of today." Even Harry Truman said "One of our troubles today stems from the fact that too many adults, and not enough children, believe in Santa Claus."

It is rather discouraging to note that speeches on both sides talk of increased spending and higher taxes, but say nothing about reducing spending by economies which everyone knows are possible but which may be politically distasteful.

△ A friend of ours points out how this equality of the sexes business has been overdone: When a little girl plays with dolls, it's normal and healthy. When a big man does, it's normal, too—but dangerous.

△ F. A. Dudderar, general superintendent of U. S. Steel's Gary Steelworks, blames most industrial accidents on four "imps": impatience, improvising, impunity and impulsiveness.

△ Figures from the National Safety Council show Gary steelworks the safest big steel mill in the country, with a frequency rate of 0.35 disabling injuries per million man-hours between mid-1959 and mid-1960. Gary established a record of 17,133,243 man-hours worked without a disabling injury between December 28, 1959, and May 28, 1960.

△ In case anyone is interested, we've just learned that dieters in the United States spend $750,000,000 annually on reducing aids.

△ Someone says that sneaked snack is the pause that refleshes.

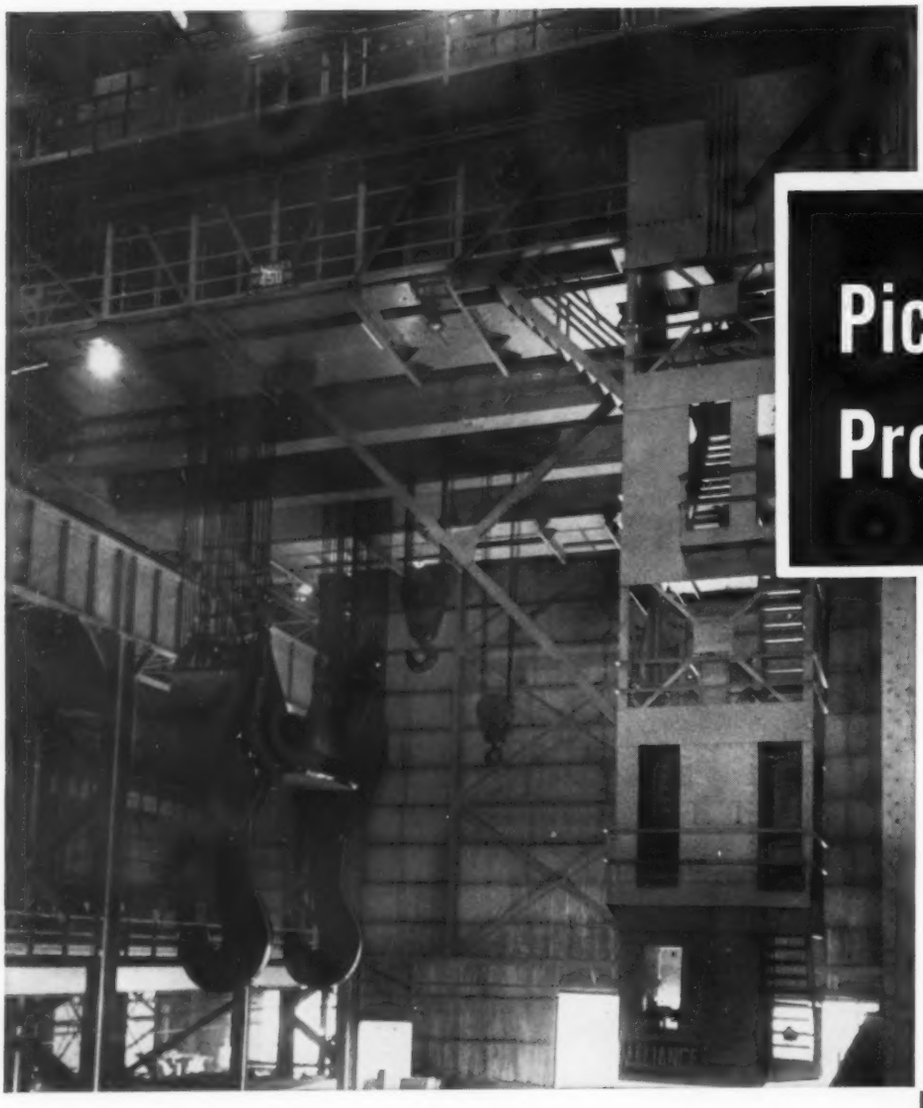
△ The Value Line Investment Survey says "Steel is a retrogressive industry: the rate of growth in steel use has not kept pace for many years with the increase in durable goods production." The trend of steel production in the United States has been irregularly sidewise over the past decade. Steel production in 1956–60 will total almost exactly the same as in 1951–55. In sharp contrast, over-all durable goods production increased some 12 per cent between the two periods, and total industrial production, including soft goods, moved up 16 per cent.

Although the ability to raise prices has been seriously impaired by present excess capacity and by long term threat of accelerated substitution of competing materials for steel, the Survey looks for some needed price increases—perhaps $4 a ton.

△ The Houghton Line comes up with a startling prediction: The next U. S. president will have two N's in his name.

△ Some 400 corporations, representative of U. S. industry will spend an average of 10.7 per cent more for development of new products and processes in 1960 than in 1959, according to a survey by American Management Association.

△ *Typographic* says the reason so many men's suits look about the same as last year's is that so many of us are wearing the same ones.



Pick-up for Productivity...

Install
WAGNER *POWERED*
hydraulic brakes on busy cranes

Are shuddering, crane-wrenching stops . . . skid-by-the-spot stops . . . premature stops . . . reducing the productivity of your operation? Put an end to them. Equip your busy cranes with Wagner *Powered* Hydraulic Crane Bridge Brakes.

Wagner *Powered* Braking Systems reduce wear on equipment. Smooth power operation ends bridge motor plugging with its resultant damage to both motors and gears. Brakes don't drag and unnecessarily wear wheels and linings. You get safer, more efficient crane operation. Operators can stop cranes consistently and smoothly . . . productivity is increased, particularly in operations where frequent starts and stops are necessary, where close spotting is required, where heavy equipment is involved.

Your operators perform more efficiently, too, because there's far less fatigue. They can stop cranes with an easy touch of toe on a button while the heel rests comfortably on the floor. Several brakes can be operated from one station.

These power units can be added to your present Wagner Hydraulic System. Let your nearby Wagner Industrial Brake Application Engineer show you how easy, fast and economical such an installation can be. There are Wagner branches in 32 principal cities.

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Whether your "National" electrodes are received by rail or truck, each one is protected by specially designed end caps to keep dirt and dust out of the socket, and to protect against end-face chipping. To facilitate handling, the majority of electrodes are palletized.

In attempting to offer new savings to electric furnace operators, in 1957, NATIONAL CARBON in a joint effort with Evans Products Company, developed damage-free gondola cars for electrode shipments. This equipment requires minimum dunnage yet carries substantially larger loads. Unloading is quick and simple. Recently, in co-operation with a leading railroad, NATIONAL CARBON is making west coast shipments of electrodes 20 inches in diameter and smaller in new high-side, damage-free gondola cars. The increased capacity of these cars makes possible a reduced transcontinental freight rate on shipments in excess of 110,000 pounds.

These developments are efforts by NATIONAL CARBON to offer important new savings to electric furnace operators, whether they occur in packaging and delivery methods . . . in improvements in product quality . . . in the results of an overall service program or in the facilities of our five domestic production plants. For details, contact National Carbon Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. In Canada: Union Carbide Canada Limited, Toronto.

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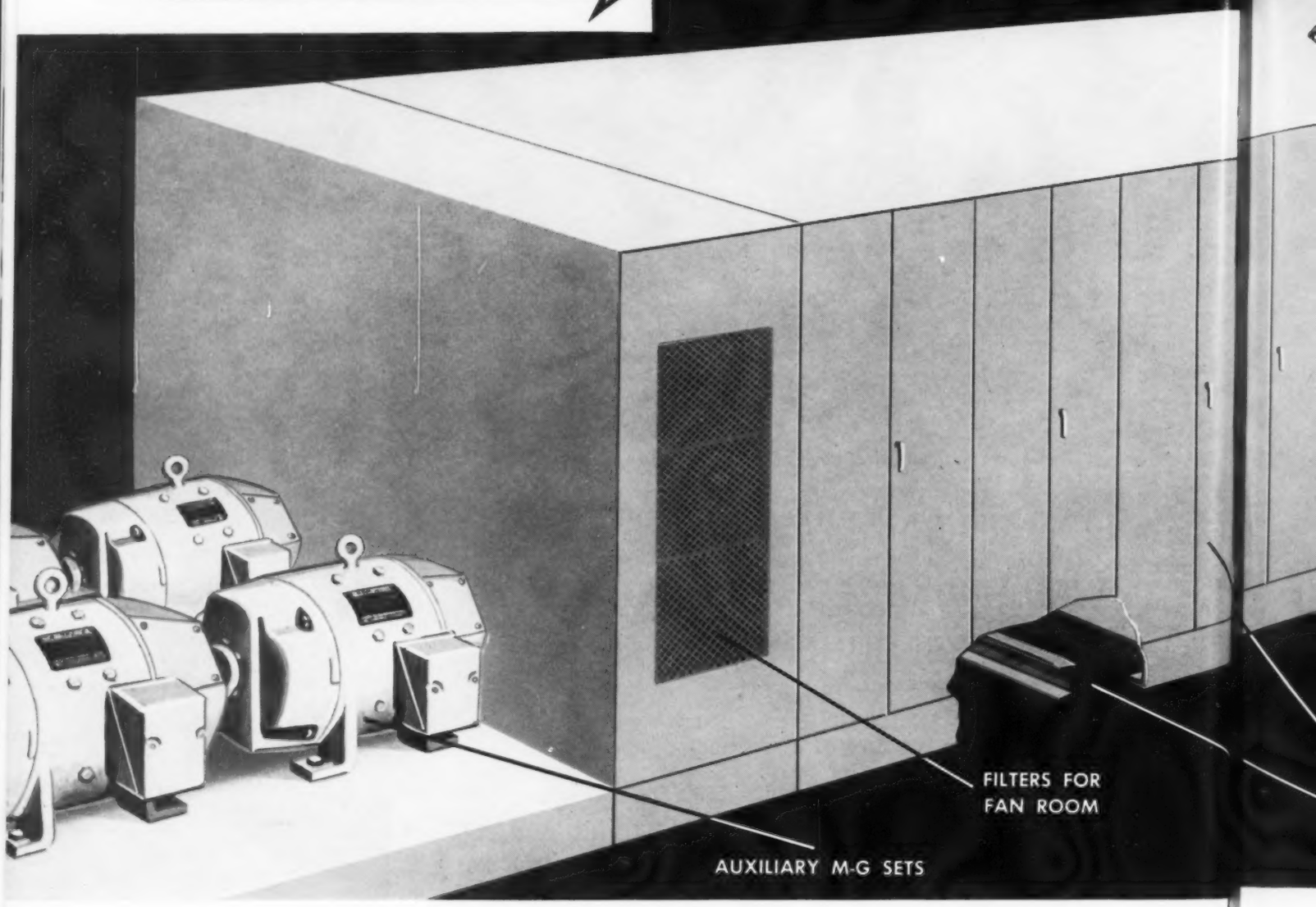
AUTOMATED BY GENERAL ELECTRIC



A NEW PRACTICE IN PROCESS-LINE CONTROL

G-E "packaged" motor-control rooms reduce

The latest innovation in modern steel-mill process-line control is General Electric's new "packaged" motor-and-control room. This novel design, developed jointly by General Electric and Jones and Laughlin Steel Corp., groups all controls and m-g sets into one compact centralized unit. The above unit will be installed at J&L's Aliquippa, Pa., works, as part of their continuing facilities-improvement program. Previously, the installation expense on this equipment often matched or exceeded the actual cost of the equipment. The new G-E motor-control room design cuts installation costs as much as 40 percent!

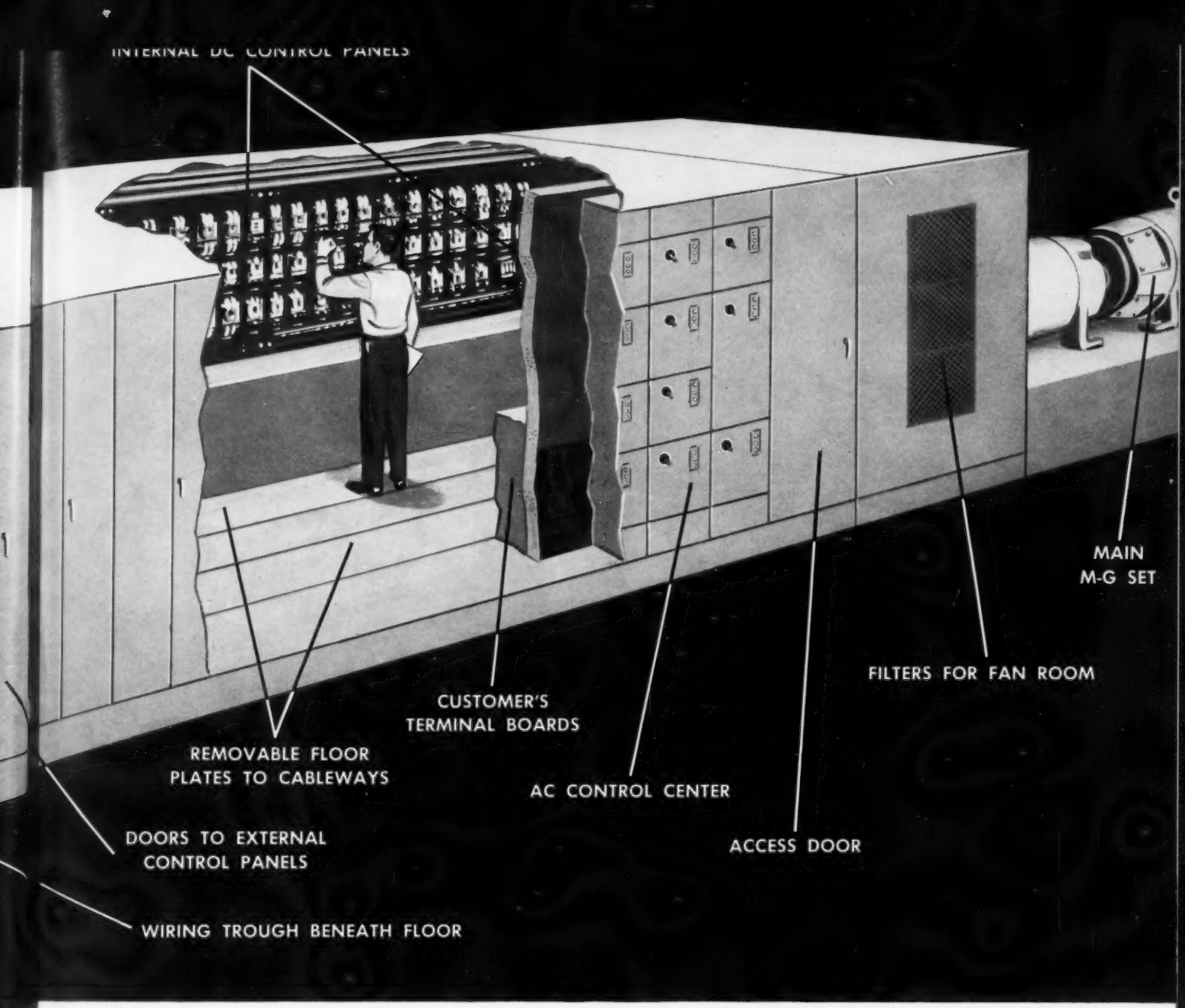
HERE'S WHY INSTALLATION COSTS ARE LOWER

Substantial savings on installation expenses can be realized through these features:

Independent control unit—The General Electric motor-control room is a completely co-ordinated, pre-assembled unit in itself, and in many cases, eliminates the need for a separate motor room. Since the motor-control room is self-contained, it may be located either near the driven equipment or in some previously unused area of the mill.

Field wiring is reduced by one-third or more—All internal connections are made and tested before the motor-control rooms are shipped. The only field wiring required is the connection of the power source and the leads to the operators' stations and the drive motors.

Construction engineering costs reduced—General Electric's grouped control concept enables the mill to know its conduit requirements much sooner. Thus, fewer,



installation costs as much as 40 percent!

less-complex construction diagrams are needed, and actual construction can begin at an earlier date.

Common base minimizes installation time—This new "packaged" motor-control room, delivered on its own self-supporting platform, can be immediately set on a normal mill floor. It does not require expensive, specially-constructed foundations. With m-g sets built and shipped on a common base, the need to align them at the mill site is eliminated. In addition, regulating equipment is factory-tested prior to shipment, further expediting startup time.

For all the details on this new technique in process-line control, contact your G-E Sales Engineer today! General Electric Company, Industry Control Department, Salem, Virginia, and Direct Current Motor and Generator Department, Erie, Pennsylvania. 785-7

Progress Is Our Most Important Product

GENERAL ELECTRIC

Stub at left shows average waste with conventional cutting carbons; piece at right shows small amount of waste with Kostkutter Rods.

"We save 20 to 25% over conventional cutting carbons with Speer's new KOSTKUTTER RODS*"

says Benjamin Desper, Cleaning Room Foreman, Atlantic Steel Castings Co., Chester, Pa.

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Kostkutter Rods are available only from Speer. Buy them in diameters of ½", ⅝", ¾" and 1". Standard cutting carbons are also available at slightly lower prices.

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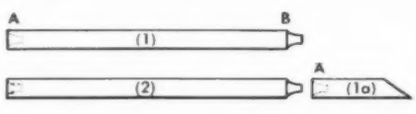
Each Kostkutter Rod has a tapered hole in one end (A) and a tapered projection at the other end (B) as shown in Diagram 1. The rod is clamped into the torch and used in the normal way. The stub end (Diagram 1a) which, with conventional cutting carbons would be wasted, is removed from the torch and attached to the end of a new Kostkutter Rod (Diagram 2). The tapered end of the new rod slips easily into the tapered hole at the end of the stub and is held firmly by friction. The new rod, with the stub attached, is then clamped into the torch and practically the entire stub is used up instead of being discarded.



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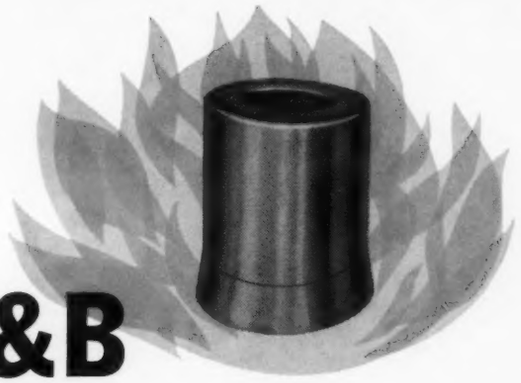

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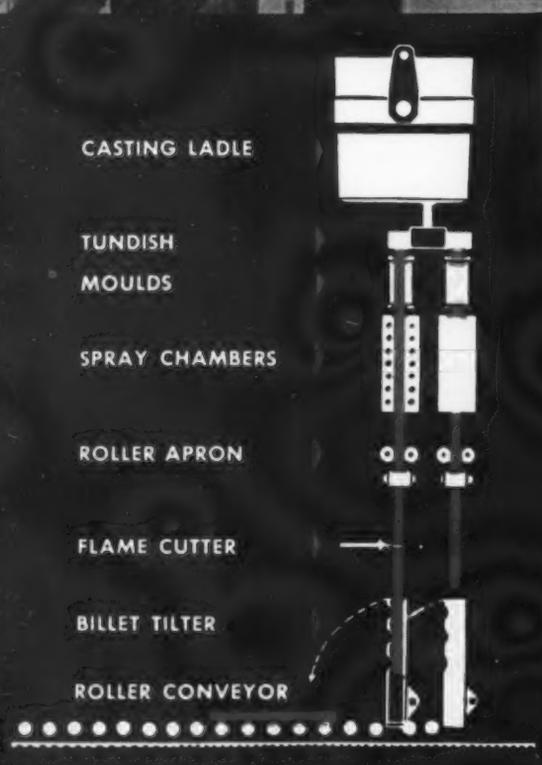

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patent reviews

By MELVIN NORD, Patent Attorney, Detroit, Mich.

Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents . . . . patents reviewed cover period May 3, 1960 to May 31, 1960

HOT ROLLING OF METAL POWDER

△ U. S. 2,935,402, issued May 3, 1960 to Frederick J. Trotter, Richard B. Montgomery, Lincoln T. Work and Gerhard Naeser, assigned to Mannesmann Aktiengesellschaft and Chemetals Corp., describes a process for converting metal powders into wrought metals such as strips, rods, wires, and sheets, by sintering the metal powder and hot rolling the sintered bar.

As shown in Figure 1, the wet powder is placed in a centrifuge 1 to wash the powder free of any contaminants. The powder, when taken from the centrifuge usually contains about 5 to 10 per cent moisture. The moist powder is then passed to a suitable drying apparatus such as the rotary dryer 2 shown in the drawing. The powder emerging from the dryer contains about 0.5 to 1.0 per cent moisture. The powder 3 is then transferred while still hot from the dryer onto a continuous conveyor belt 4.

As it is at times difficult to deposit the powder onto the conveyor with the uniformity desired for subsequent operations especially when strip of considerable width is to be produced, the powder may be smoothed over or flattened by rolls 7.

It has also been found that if the powder mass is subjected to tensile forces prior to the sintering and rolling thereof, that it has a tendency to crack. Any cracking in the powder mass may subsequently show up in the completely consolidated product as thin or weak spots. It is thus highly advantageous to prevent any cracking of the powder mass prior to the subsequent sintering and rolling operations. By utilizing the rolls 7, to subject the powder mass to a very mild compressive force, any tendency for the powder mass to crack is greatly minimized. Thus the rolls 7 not only even out any irregularities in the thickness of the powder being fed, but also serve to prevent cracking by making sure that the metal is properly distributed when fed through the apparatus.

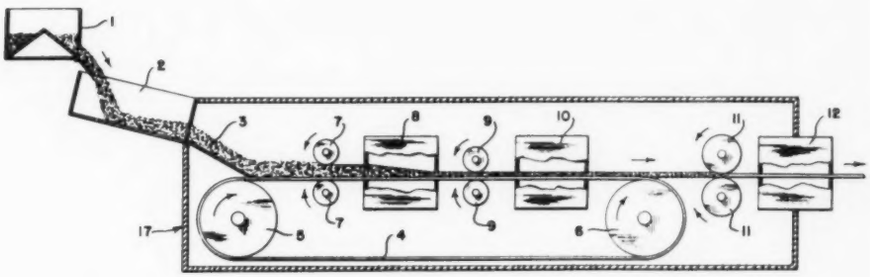


Figure 1

After the rolls 7 have performed their smoothing operation on the powder, the powder is continuously fed into a suitable furnace 8. This heating of the powder causes the particles to sinter into a bar, and considerable shrinkage of the powder occurs. This shrinkage of the metal powder may cause some irregularities to form in the bar, in which case it is advantageous at this point to remove the unevenness in the bar by rolls 9.

The partly compacted porous bar is then passed continuously through a second furnace 10 in which the bar is rapidly heated to a higher temperature. Due to the partial consolidation by the rolls 9, this second heat treatment may be very rapidly accomplished due to the higher heat conductivity of the slightly compacted bar issuing from the rolls 9.

Once its mass has reached the required temperature, the bar can be passed immediately through the rolls 11. The bar compacted in this manner has been found to attain a high degree of densification during a single pass through the pressure rolls.

After the bar leaves the rolls 11, it is continuously passed through a cooling chamber 12 and may then be further worked if desired by conventional rolling procedures.

IMPROVED BESSEMER PROCESS FOR MAKING STEEL

△ U. S. 2,936,230, issued May 10, 1960 to Bernard M. Larsen and assigned to United States Steel Corp., provides an improved bessemer-type apparatus which: (a) minimizes heat losses from the vessel and (b) utilizes all the potential heat of oxidation, thus permitting a larger proportion of scrap in the charge. In addition, control of composition, comparable to open hearth operation, is achieved.

The vessel 10 and lance 12 are shown in Figures 2 and 3. The vessel 10 is first preheated to about 2500 to 2800 F in any conventional way, such as by insertion of a fuel-oxygen burner in place of the lance 12. The vessel is charged with ferrous material, which can include

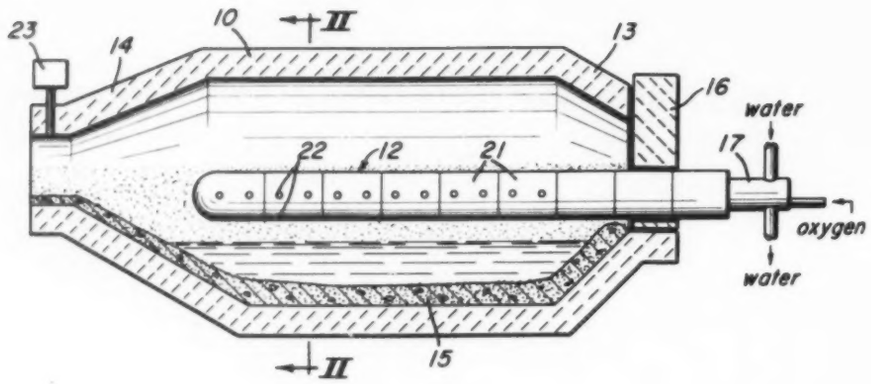


Figure 2

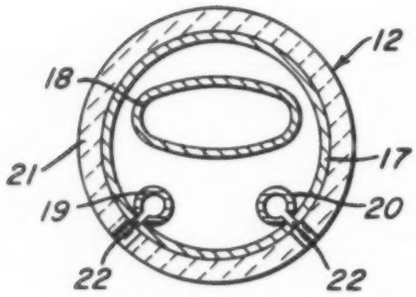
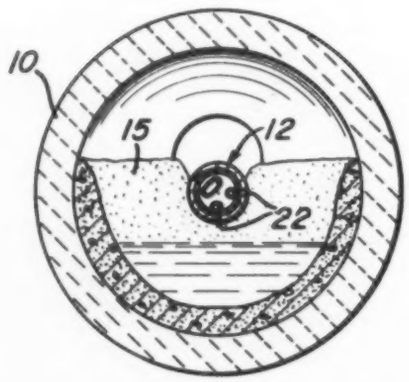


Figure 3

up to about 30 per cent scrap and the remainder hot metal, plus a flux of burnt lime in an amount equivalent to about 60 to 80 lb burnt lime per ton of steel produced. The silicon content of the initial charge is about 0.60 to 1.2 per cent. The door 16 is installed and the lance 12 inserted in the position shown in Figure 4, that is, with one row of jet openings 22 directed vertically downward at the surface of the charge.

The oxygen inlet tube 19 or 20 whose jet openings are directed downwardly is connected to a source of commercially pure oxygen under relatively high pressure sufficient to deliver oxygen at a rate of about 15 to 18 lb per hour per opening. At the same time the vessel 10 may be rocked on its longitudinal axis. Silicon and manganese in the charge oxidize and furnish heat for melting the solid constituents. The combined effect of the rocking motion and the subdivision of the oxygen into many small streams prevents over-concentration of oxygen at any one point. The lime combines with silica formed by selective oxidation of silicon and forms a liquid slag, which also contains some iron oxide and manganese oxide. At this stage there is very little oxidation of carbon, and little fuming. However, some carbon monoxide forms and may be burned with low pressure oxygen introduced via the other oxygen inlet tube 19 or 20 whose jet openings are directed toward the side. Preferably the oxygen introduced in this way is sufficient to leave a small amount of free oxygen (1 to 2 per cent) in the off-gases from the vessel, as indicated by the recorder 23.

Figure 4



After about 6 to 12 min the silicon content of the charge drops to about 0.05 to 0.20 per cent, the volume and the fume content of the off-gases increase, and the rates of manganese and carbon oxidation increase. Typically a bath whose initial temperature is 2300 to 2400 F reaches a temperature of 2500 to 2700 F at this stage and the solid materials are mostly dissolved. With the vessel stationary, the lance 12 is withdrawn, whereupon the vessel may be tilted toward the charging end to pour off most of the slag. Additional lime may also be charged.

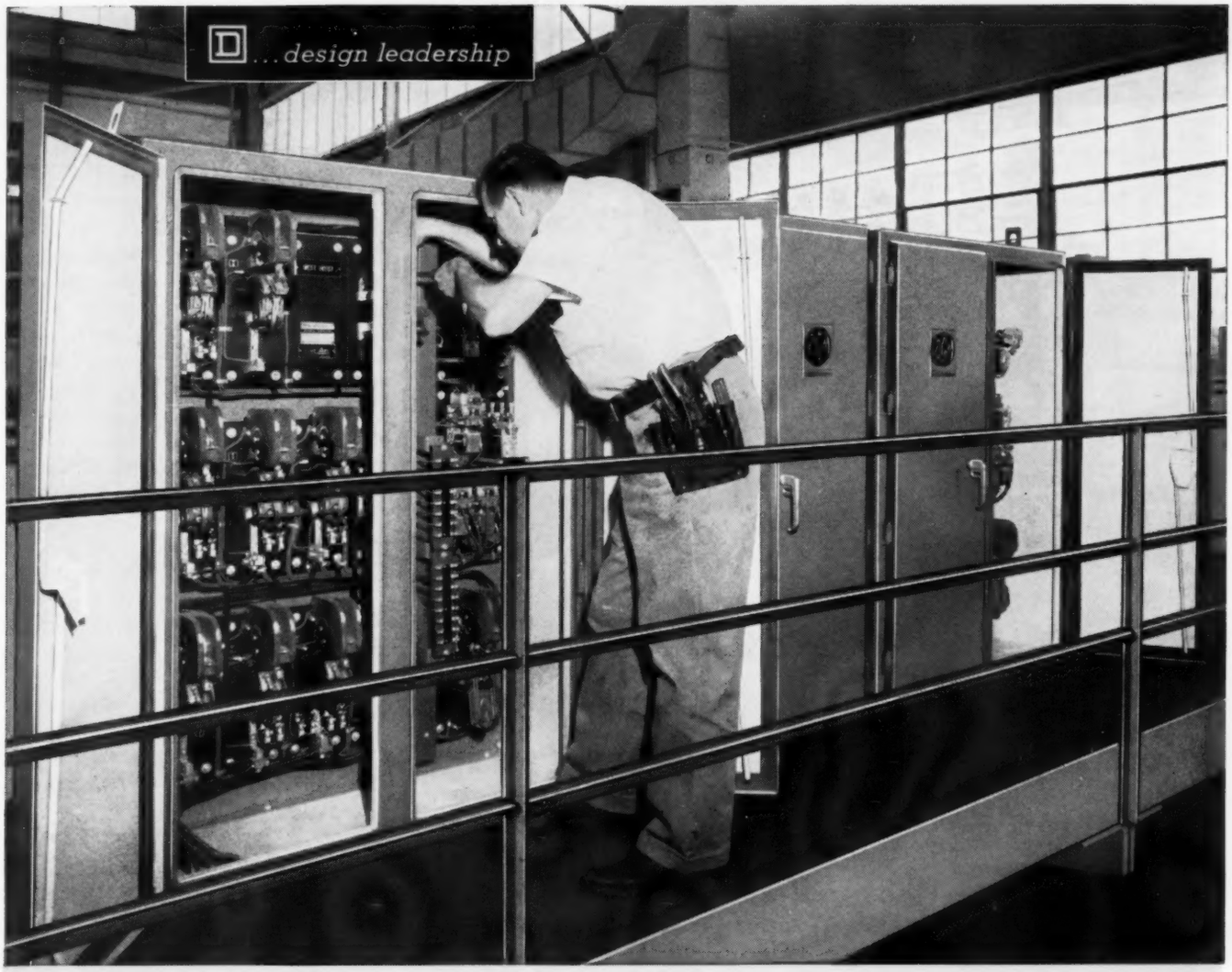
The lance 12 is reinserted in the vessel 10, but with the jet openings of both tubes 19 and 20 directed obliquely downward. Both tubes are connected to a source of commercially pure oxygen under low pressure sufficient to deliver oxygen at a rate of about 5 to 10 lb per hour per jet opening. The actual oxygen input is adjusted to yield 1 to 4 per cent free oxygen in the off-gases from the vessel. The vessel may be stationary or may be rocked as before. As the slag absorbs oxygen and the silicon in the metal drops to a few hundredths of one per cent, a carbon boil slowly begins. The boil increases the rate of oxygen absorption, and rocking of the vessel can be stopped. The jets blow oxygen gently over the slag surface, and little or no oxygen contacts the metal directly. Instead oxygen reaches the metal exclusively by absorption and diffusion plus convection through the slag layer. The rate of boil increases, and oxidation of phosphorus, manganese and carbon proceeds, the carbon dropping at a rate as high as 300 points (3.00 per cent) per hour. Oxygen above the bath effectively oxidizes the carbon monoxide evolved from the metal to carbon dioxide.

After 40 to 80 min the lance is rotated 180 degrees. The oxygen rate is diminished to leave only a fraction of one per cent free oxygen in the off-gases. As the boil dies down, the oxygen is cut off and the lance removed. The bath is now checked for temperature, carbon content, and slag basicity. More cold scrap or pig or lime can be charged. Finally the lance is removed to allow a slow approach to final slag composition and carbon level in the refined bath. The vessel is tilted toward its pouring end to remove the charge.

The total heat time is about 2-2½ hours. However, the composition of the final product can be controlled as closely as in an open hearth process. The amount of cold material that can be melted is larger than in the bottom or side blown processes, and at least as large as in other bessemer processes. The amount of fine dust carried from the vessel is but a small fraction of that from other bessemer processes, and there is less erosion of refractory surfaces.

REFINING OF THOMAS PIG IRON

△ U. S. 2,935,398, issued May 3, 1960 to Hermann Brandi, Heinz Hofges, and Egon Kohler, assigned to Phoenix-Rheinrohr Aktiengesellschaft Vereinigte Hutten- und Rohrenwerke, describes a process



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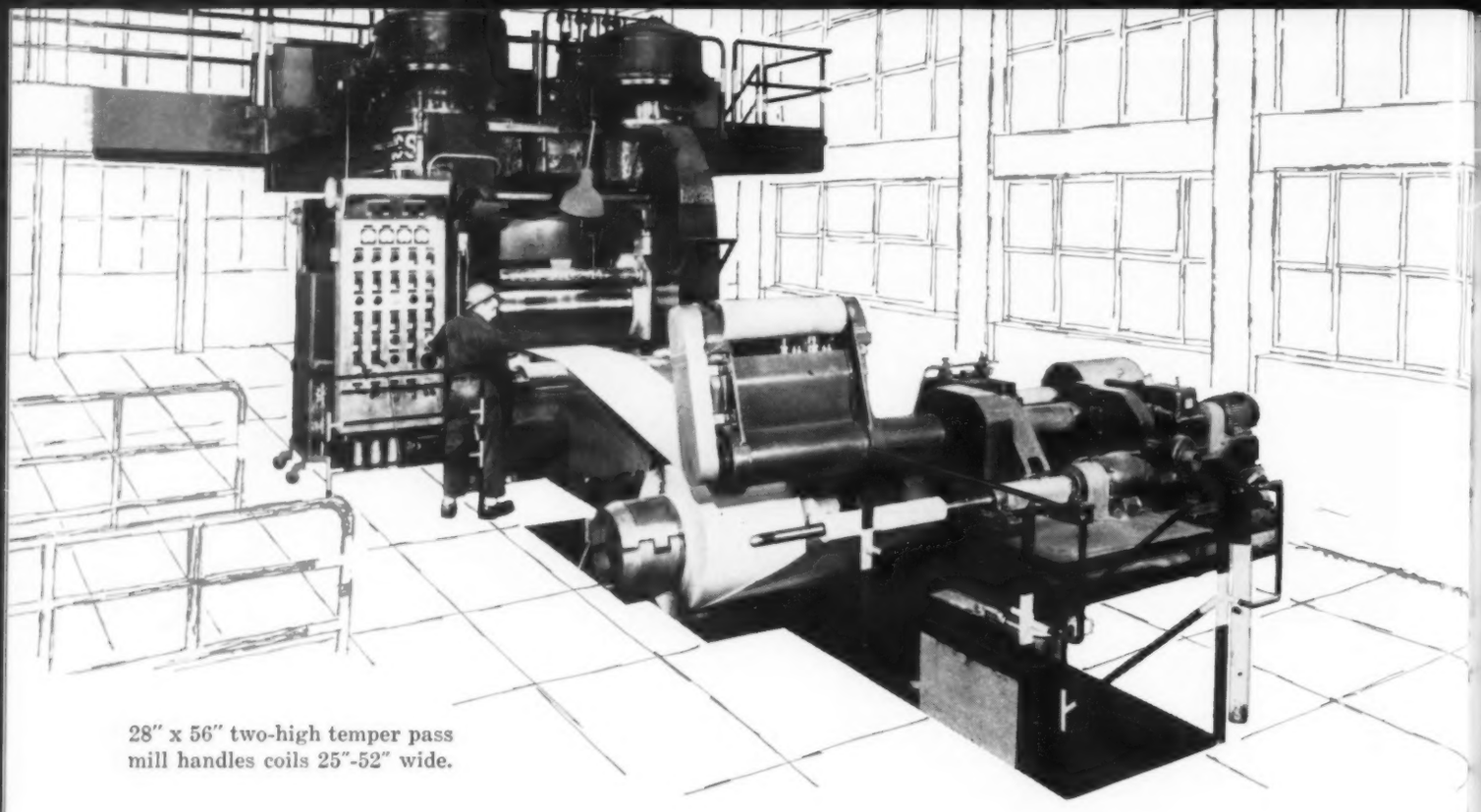

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Another Bliss temper mill is paying similar dividends in Gary's continuous pickling line. Key addition of an April '59 expansion program, this 34" x 76" two-high mill with husky entry and delivery bridles enables Gary to handle strip 18"-62" wide, in thicknesses from .059"-.187". It reduces stock 1½-2%, serving to fracture the scale, thus resulting in less pickle liquor required and higher pickling rate.

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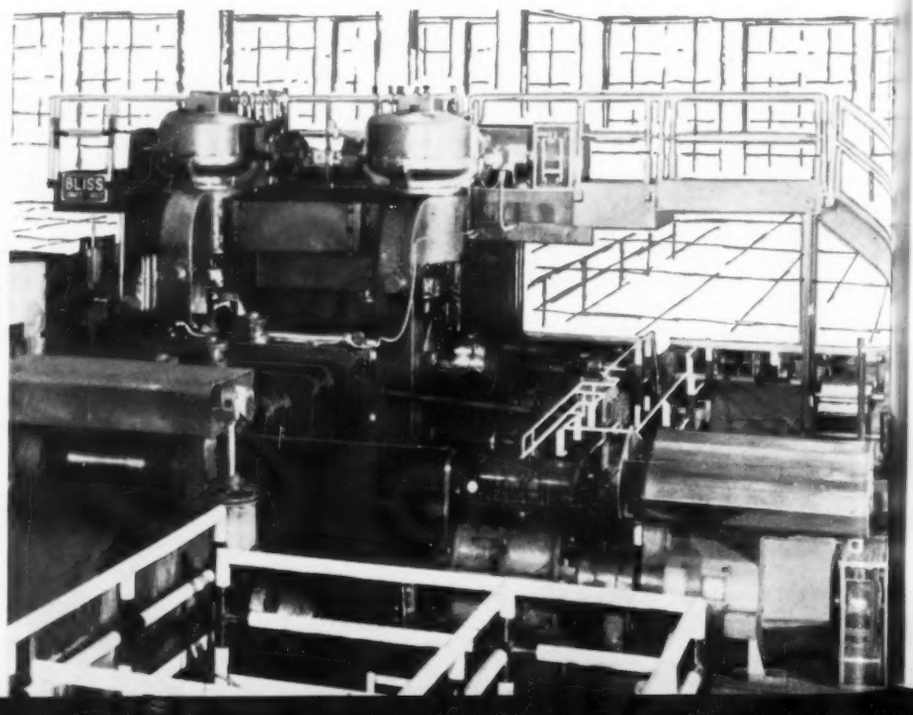


34" x 76" two-high mill in Gary's continuous pickling line descales and tempers at the same time.

for refining Thomas pig iron by blowing with oxygen.

A Thomas pig iron with 3.60 per cent C, 1.75 per cent P and the usual contents of manganese, silicon and sulphur after the usual addition of lime is blown with air enriched with oxygen from below the upright positioned converter to a carbon content of about 0.7 per cent in the basic converter in a first stage which lasts about 7½ minutes. After this the iron contains about 1.4 per cent phosphorus. The converter is then tilted and the charge is refined with oxygen from the surface of the melt, the converter acting as a kind of open hearth furnace. The process is carried out in such a way that, by combustion of the necessary amount of iron, a thinly liquid iron-containing slag is quickly formed. Then, on further blowing with oxygen on the surface of the charge, a rapid combustion of the phosphorus takes place under this slag, whereas the carbon content of the charge only slightly decreases relative thereto. At the end of this refining period, which lasts about 15 minutes and constitutes the second stage of the process, the charge still contains about 0.3 per cent carbon, about 0.07 per cent phosphorus, about 0.03 per cent sulphur and about 0.003 per cent nitrogen. The iron content of the final slag is about 17 per cent.

In a third stage in which the converter is set upright for a short time the charge is blown from below for about half a minute. The carbon content of the charge is thereby lowered to about 0.15 per cent and the phosphorus content to about 0.04 per cent without altering the nitrogen content of about 0.003 per cent.

The converter can then be tilted once more and the charge again blown with oxygen, the slag having previously been changed. After this refining step the charge contains about 0.10 per cent of carbon, about 0.02 per cent of phosphorus, about 0.018 per cent of sulphur and about 0.003 per cent of nitrogen. If the converter is set upright once more for a short time these values are further improved and it is possible to adjust the carbon content almost instantaneously to any practically desirable low value.

Figure 5 shows how the molten

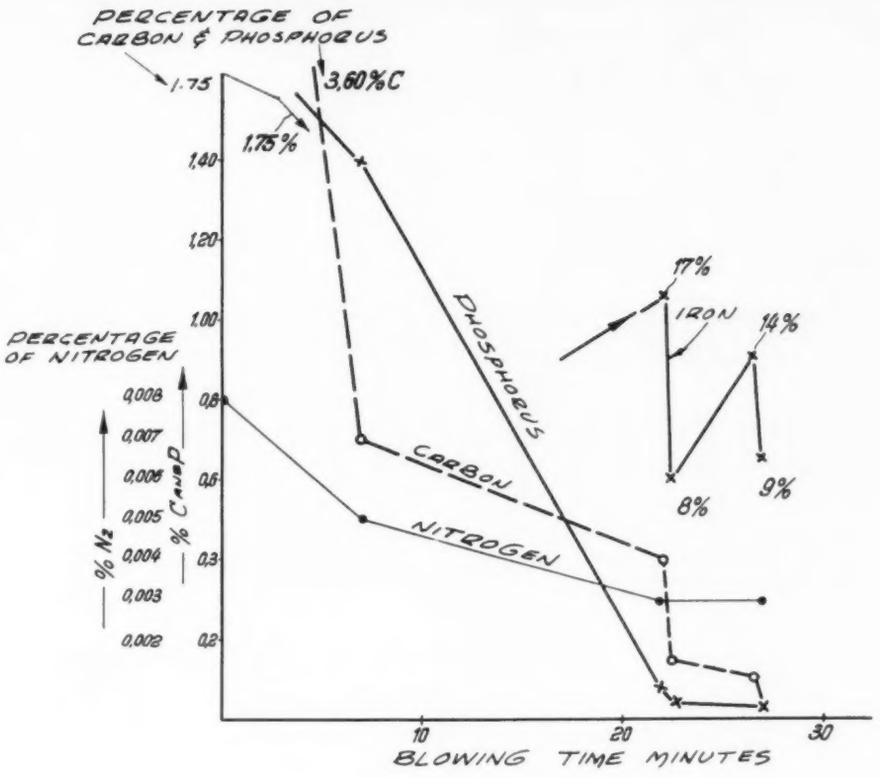


Figure 5

metal and slag co-operate with one another during the blowing with air and oxygen. At the end of the second stage, i.e., the oxygen stage, there is present, as mentioned above, a slag having a high content of iron, namely, about 17 per cent Fe from which, however, in a short after blowing stage, the iron is reduced by the carbon to 8 per cent. In the second top blowing period, the iron content increases again to 14 per cent and the slag is tapped with an iron content of about 9 per cent when the converter is set upright for the last time.

The diagram shows the extraordinary advantages of the process of the invention. They are not only that the process can be carried out with the usual apparatus in an extremely simple manner, but above all, in the control of the phosphorus and carbon combustion. Of these the former takes place extremely quickly and the latter proceeds in such a way that a high-grade steel is produced at the end of the period when the converter has been set upright again for the first time, which steel can then be still further improved as regards its phosphorus content by a subsequent top blow.

OPERATION OF BLAST FURNACES

△ U. S. 2,938,782, issued May 31, 1960 to Harry A. Toulmin, Jr., assigned to The Commonwealth Engineering Corp., provides a process for operating a blast furnace utilizing improved fuel, whereby temperatures on the order of 4000 to 6000 F or even higher, may be produced within the furnace. Such high temperatures make it possible to smelt ores containing aluminum, titanium and the like which require very high temperatures to calcine and reduce the oxides to metal. The fuel is a mixture of metal dust, coal dust, metallic soap and air, oxygen or hydrogen, the solid constituents of the fuel being in the form of fine (preferably a micron or less) size particles which are mixed with hydrogen and air and introduced in the form of a blast through the tuyeres. The fuel may be in the form of a slurry in kerosene.

In Figure 6, a shaft type refractory lined blast furnace structure 10 is illustrated having a charging hopper 11, and downcomer or gas takeoff 12 at the top of the furnace. For closing the furnace, a bell-shaped valve 14 is provided, as shown. Metallurgical ore, coke and fluxing constituents, forming the material 15 to be smelted, is conveyed to the top of the furnace in suitable trucks 16, as hauled by a hoist 17, the material being discharged into the hopper 11.

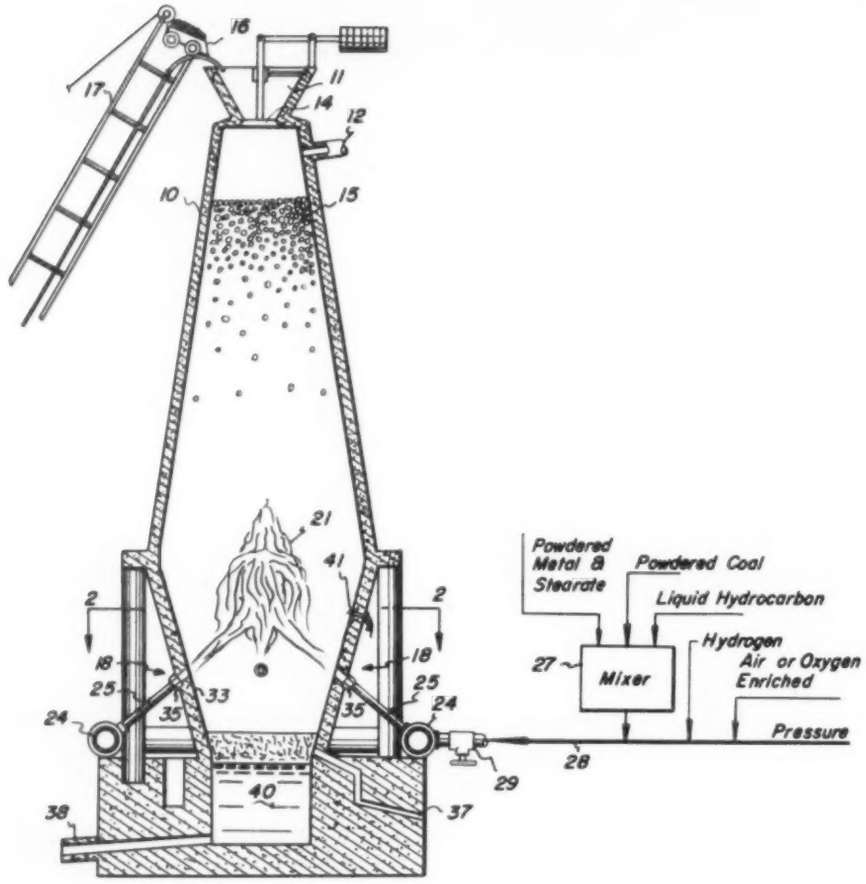


Figure 6

Tuyeres generally indicated at 18 are arranged circumferentially about the furnace at the combustion zone 20, the fuel being introduced through tuyeres spaced circumferentially around the furnace and inclined approximately 45 degrees to the horizontal. The fuel mixture is delivered from the tuyeres in the form of a blast and directed upwardly to form a cone-shaped fusion zone 21. The high temperature burning fuel mixture containing powdered metal and coal is fed to the furnace through a manifold pipe 24 which extends around the furnace, the latter being connected to the tuyeres through pipe sections 25. The tuyeres may be provided with a water-cooling jacket, as is conventional, and the cooling water force circulated about the part to prevent over-heating of the tuyeres or furnace part.

The solid and liquid constituents of the fuel are mixed and blended in a homogeneous mass in a suitable mixer, as indicated generally at 27, and delivered under pressure, e.g., 25 to 60 psi depending upon the size of the furnace, with the combustible gas to the manifold pipe 24 through pipe line 28. A valve 29 is provided in line 28 for controlling the flow of fuel to the manifold pipe 28.

The furnace is provided with drain notch 37 for draining off slag. A drain notch 38 is used for withdrawing metal from the well 40. These notch openings are temporarily closed by fire clay or the like, which is removed when it is desired to draw off slag or metal. An electrically operated resistance heater 41 is also provided to initiate the burning of the fuel.

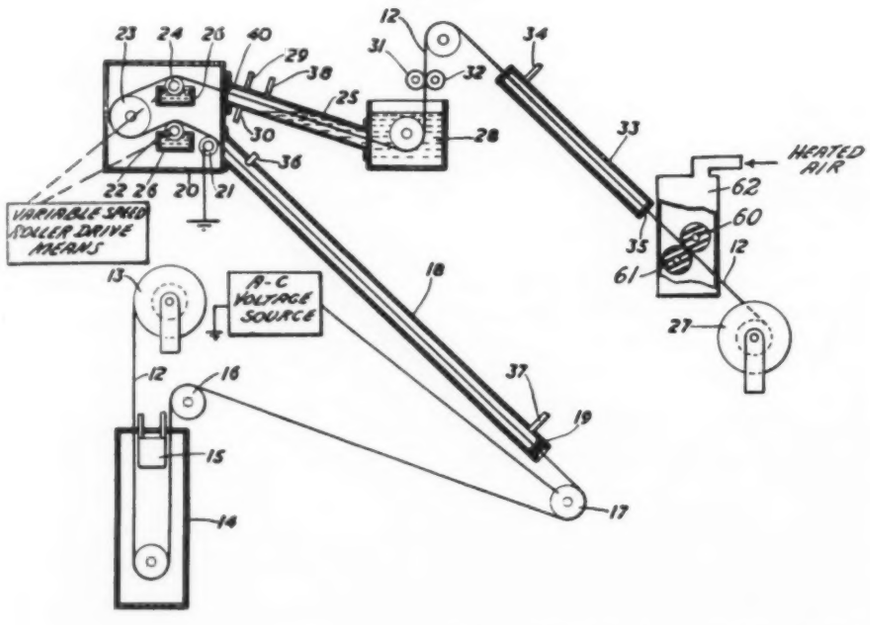
Operation of the blast furnace is similar as in the ordinary furnace, except that the fuel introduced into the tuyeres consists of a mixture of metal particles, such as aluminum, magnesium or mixtures thereof, the particles of which are preferably coated with metallic soap such as metal stearates, palmitates and the like, the same being introduced together. Preferably the metal particles are precoated with metallic soap. Powdered coal is mixed with the metal powder and blown into the combustion zone along with hydrogen and air or oxygen-enriched air to provide a completely combustible fuel mixture.

METHOD OF TINNING STEEL STRIP

△ U. S. 2,937,108, issued May 17, 1960 to Trevor C. Toye and assigned to The British Iron & Steel Research Association, provides a method of tinning steel strip. In this method the strip is not in contact with the liquid coating material for as long as in hot dip coating methods, and therefore there is much less alloy formation between the strip and the coating material.

Referring to Figure 7, the strip 12 is drawn under tension from an uncoiler 13 and through the vapor degreaser 14 which incorporates the usual cooler 15 and which removes oil layers on the strip. The strip is guided by the guide rollers

Figure 7



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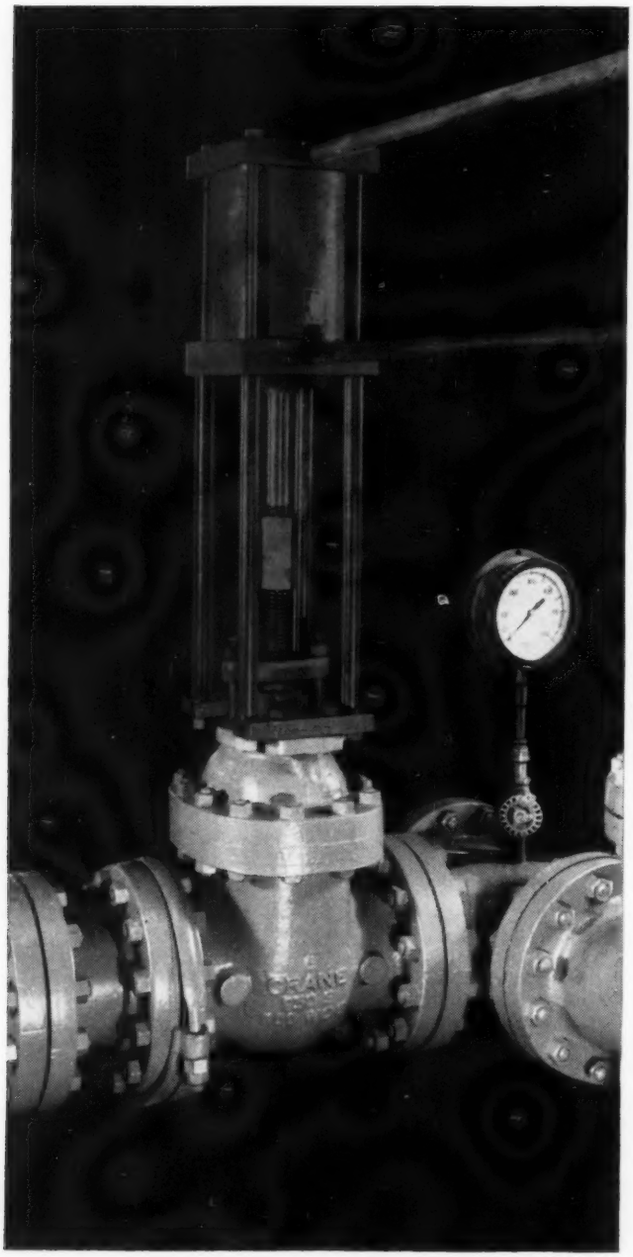

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16 and the contact roller 17 and enters duct 18 through an asbestos stuffing gland 19 which acts as a gas seal. The duct 18 is secured gas tight to a chamber 20 into which the strip passes. After entering the chamber 20, the strip passes over in sequence a contact roller 21, a tinning roller 22, a guide roller 23, and a second tinning roller 24 before leaving the chamber to the duct 25.

The tinning rollers 22, 24 apply tin to opposite sides of the strip and each dips into a bath 26 of liquid tin enclosed in the housing 23. Rollers 22, 24 are driven at peripheral speeds less than the speed at which the strip is drawn through the apparatus by a coiler 27. As a consequence, the tin picked up by each tinning roller is drawn out by the strip from the meniscus formed between the tinning roller and the strip. Effectively, the coating thus applied to the strip by the rollers 22, 24 is stretched and is solidified on the strip in the stretched condition to obtain a very thin coating. The stretched coating which is unstable is rapidly solidified on the strip to avoid dewetting by quenching in the water quench 28 into which duct 25 leads. Quenching may however also be effected by submitting the coated strip to a steam jet applied through inlets 29, 30 in the duct 25; it may also be accomplished by using an emulsion of 3 parts cotton seed oil in 1000 parts water in the quench 28, the emulsion also being sprayed on to the strip through inlets 29, 30.

After being quenched, the strip passes between the rubber rollers 31, 32 which rolls off excess emulsion if an emulsion quench has been used, and through the duct 33 through which air is drawn by an evacuating pump at 34 and supplied with warm air through 35 and which causes evaporation of any water remaining on the strip. The strip is finally coiled on the coiler 27.

A heavy alternating current is passed through the strip while in the duct 18 by means of the contact rolls 17, 21. This current raises the temperature of the strip in duct 18 to about 900 C, the temperature being measured by a pyrometer at 36. The temperature in the housing 20 itself is maintained at about 300 C, this relatively low temperature being possible by using nitrogen in the reducing atmosphere for the tinning operation. This gas mixture, which is fed into the duct 18 through pipe 37 and out of the duct 25, through pipe 38, preferably consists of equal parts of hydrogen and nitrogen which reduces oxide on the strip and at the same time enables a low temperature to be used for the tinning operation; without nitrogen the temperature could not be lowered below 400 C. The operating temperature in the housing 20 prevents excessive $FeSn_2$ formation and is checked by thermocouples (not shown) bearing against the surface of the roller 23 and in the baths 26. The pressure of the gas in the housing 20 in conjunction with a flap 40 where duct 25 joins the housing 20 prevents the entry of steam, if steam is used for quenching, into housing 20.

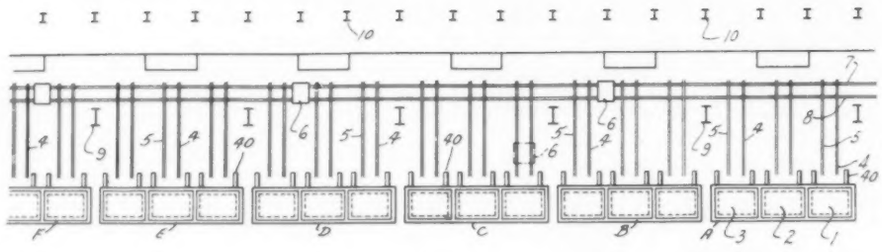


Figure 8

OPERATING MECHANISM FOR SOAKING PIT COVERS

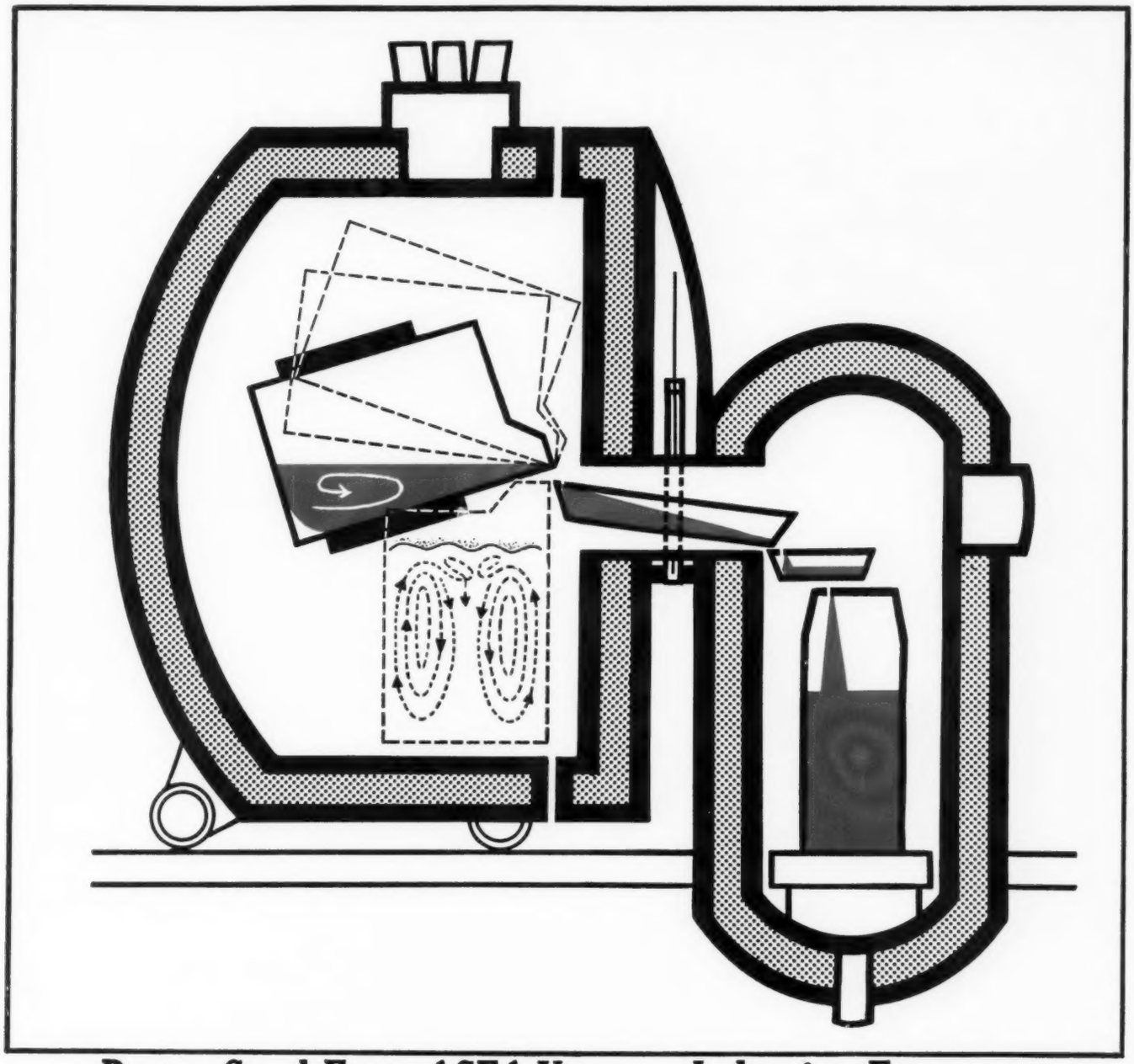
△ U. S. 2,936,906, issued May 17, 1960 to Howard F. Spencer, provides an operating mechanism for soaking pit covers.

It is an object of this invention to provide a soaking pit cover carriage power car which is adapted to operate on a series of tracks arranged with the soaking pits to move in a direction parallel with a row of furnaces and in another direction to and away from the furnaces, so that a single power car can service several furnaces.

In Figure 8, numerals 1, 2 and 3 designate three separate soaking pit furnaces marked group A, there being additional groups B, C, D, E and F of three of such furnaces shown all in a single row. Each of the furnaces is adjacent a pair of rails 4 and 5 on which a power car 6 is operable, the tracks 4 and 5 crossing rail tracks 7 and 8. Numerals 9 and 10 diagrammatically illustrate soaking pit building crane and building columns and lean-to-columns respectively.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or assignee
2,934,806	5/ 3/60	Dam setting device for coke oven gun..	Alan Wood Steel Co.
2,934,933	5/ 3/60	Bonded-wall structure for coke-oven chambers.....	Didier-Werke A.G.
2,935,421	5/ 3/60	Coating steel with magnesium.....	The Dow Chemical Co.
2,935,433	5/ 3/60	Surface hardening of cold rolls.....	Vereinigte Osterreichische Eisen-und Stahlwerke A.G.
2,935,450	5/ 3/60	Production of metallurgical coke.....	Houilleres du Bassin de Lorraine
2,936,132	5/10/60	Coiling or de-coiling apparatus for metal strip.....	The Loewy Engineering Co. Ltd.
2,936,133	5/10/60	Adjustable pay-off reel.....	United States Steel Corp.
2,937,084	5/17/60	Production of high-grade cast iron.....	Vereinigte Osterreichische Eisen-und Stahlwerke A.G.
2,937,130	5/17/60	Cyclic method for removal of impurities from coke oven tar by water washing.	Allied Chemical Corp.
2,937,424	5/24/60	Ingot mold for steel ingots.....	Compagnie de Pont-a-Mousson
2,937,425	5/24/60	Exothermic composition for production of castings.....	Foundry Services International Ltd.
2,937,555	5/24/60	Flying shear.....	United States Steel Corp.
2,937,821	5/24/60	Apparatus for coiling strip material....	United Engineering & Foundry Co.
2,938,261	5/31/60	Making and handling lathe.....	Wheeling Steel Corp.
2,938,263	5/31/60	Method of making an ingot mold.....	John C. Kruger, et al
2,938,640	5/31/60	Safety control system for coke removal plants.....	Hans Oetiker
2,938,717	5/31/60	Slag car construction.....	John Mohr & Sons
2,938,813	5/31/60	Insulated coating for silicon steel sheet.	Yawata Iron & Steel Co.
2,938,820	5/31/60	Spheroidizing steel by rapid heating...	Selas Corp. of America



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U.S. installation of 1100 kW, 5000 lbs. ASEA High Vacuum Furnace. Front View.

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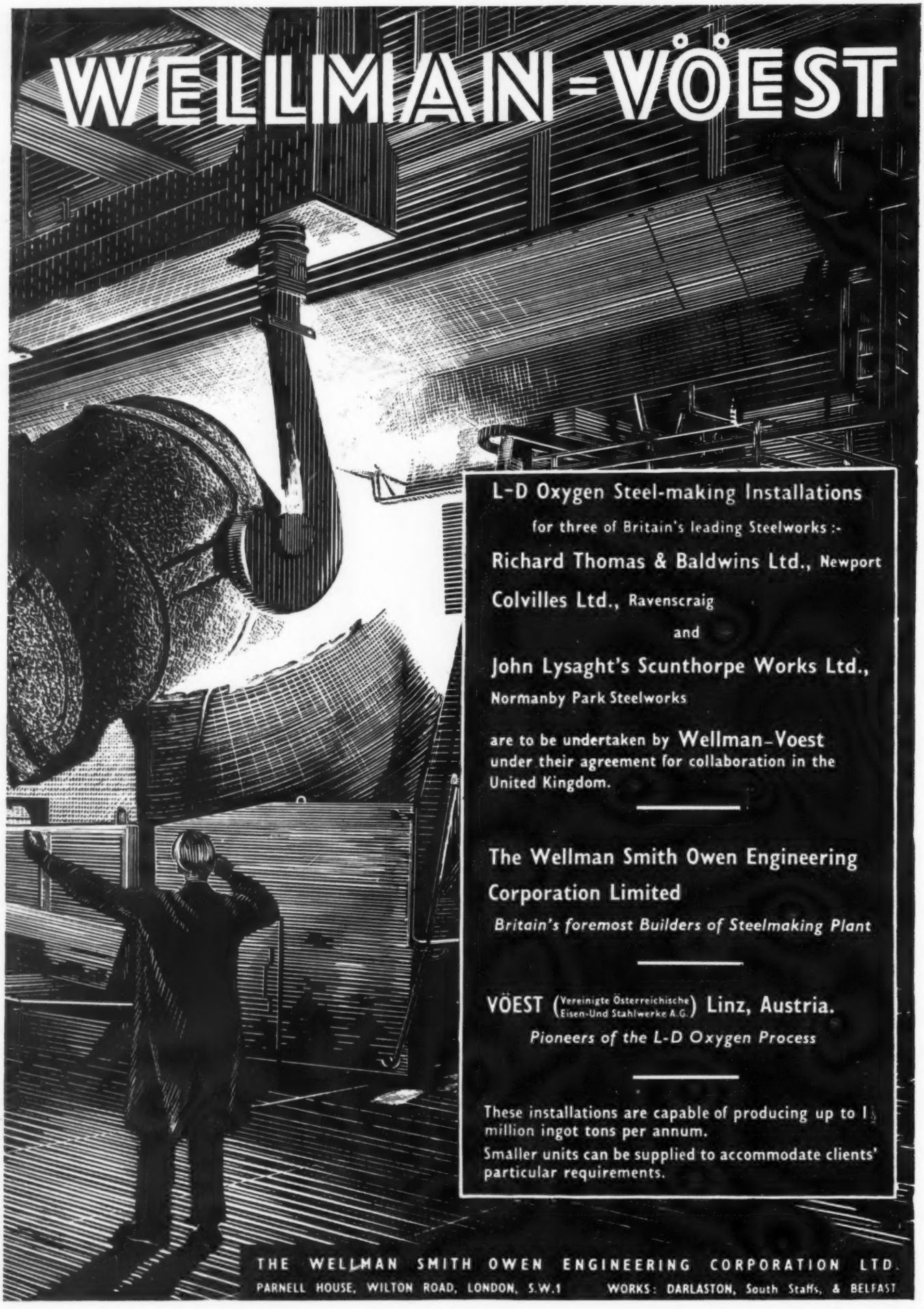
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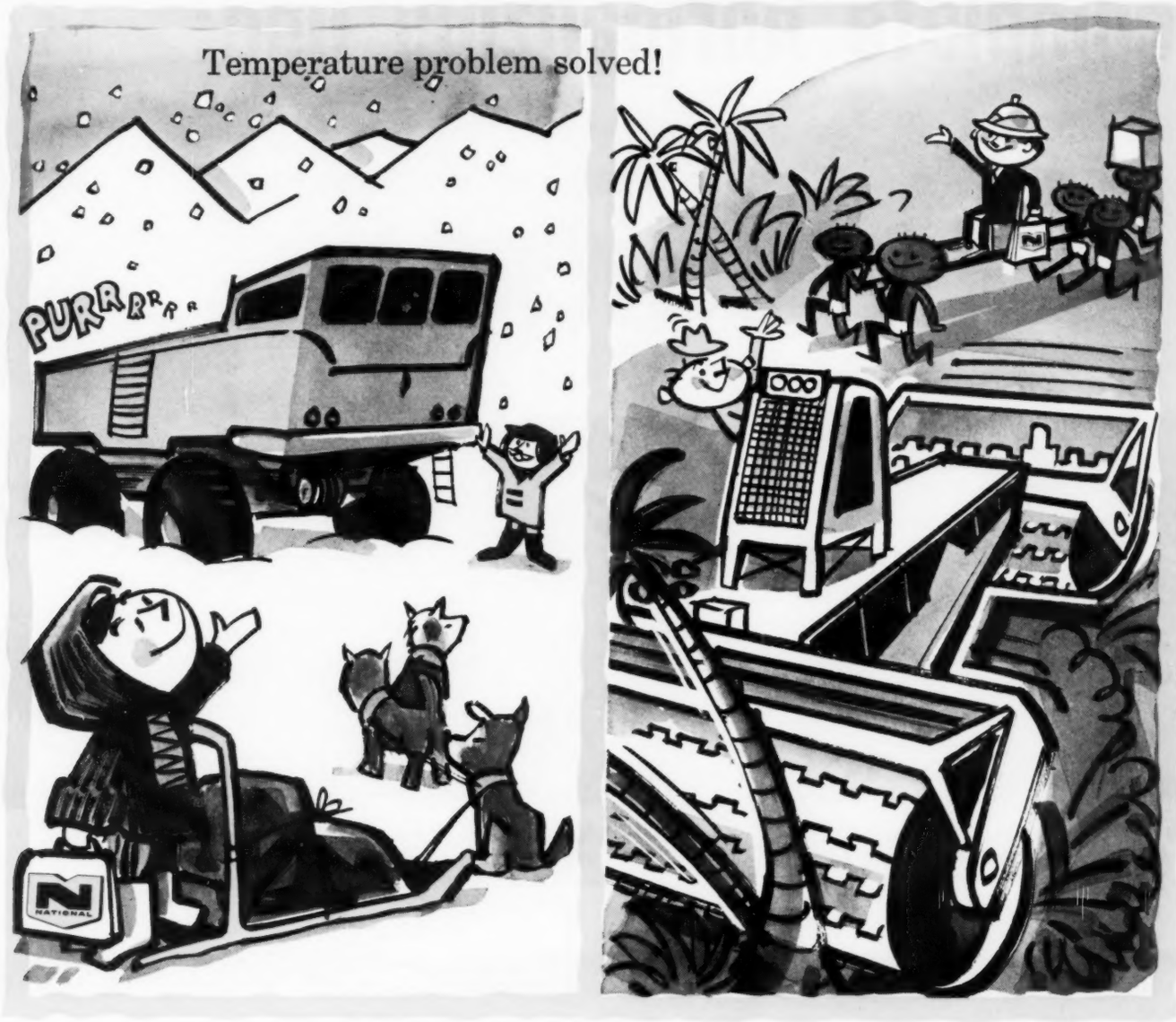

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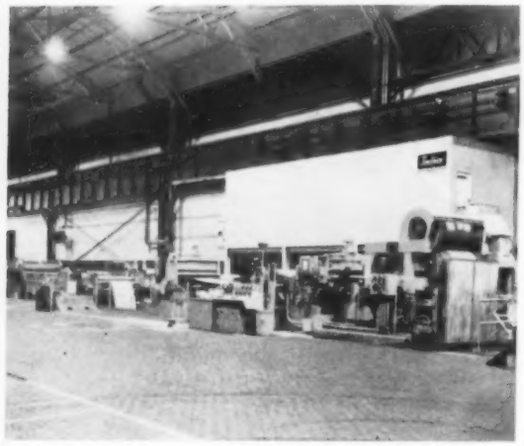
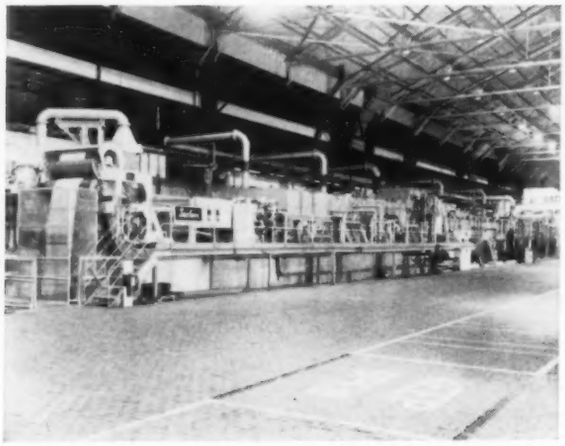
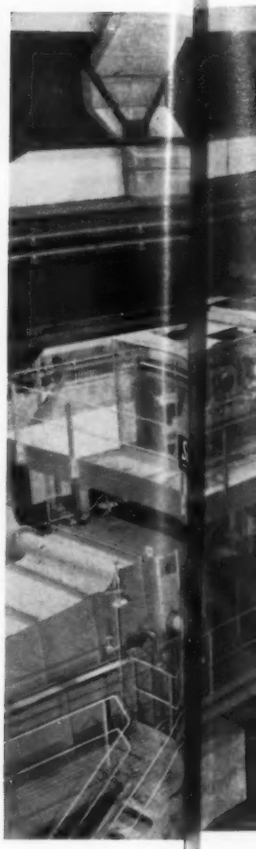
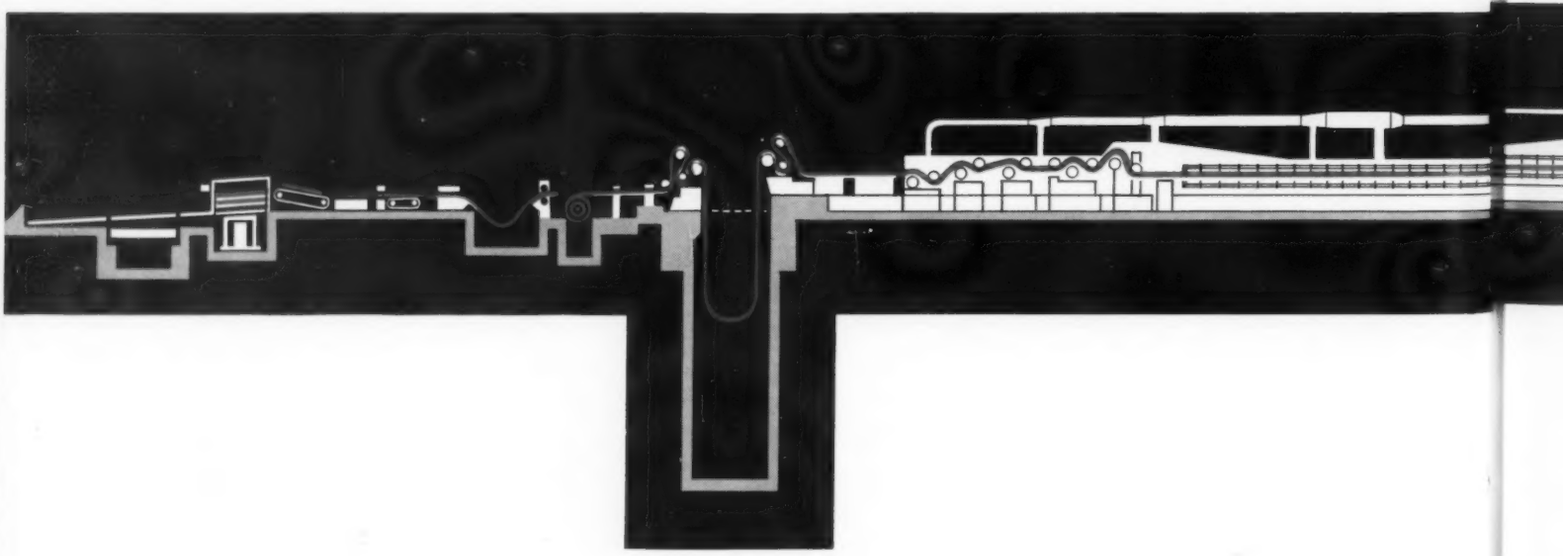


Exit end of the line, showing looping pit, "recoiler," automatic shear and sheared sheet piler.



Pickling section includes acid bath, water rinse tank, brush scrubbers, alkali tank and dryer, all installed by Surface. This view shows the exit end of the section.





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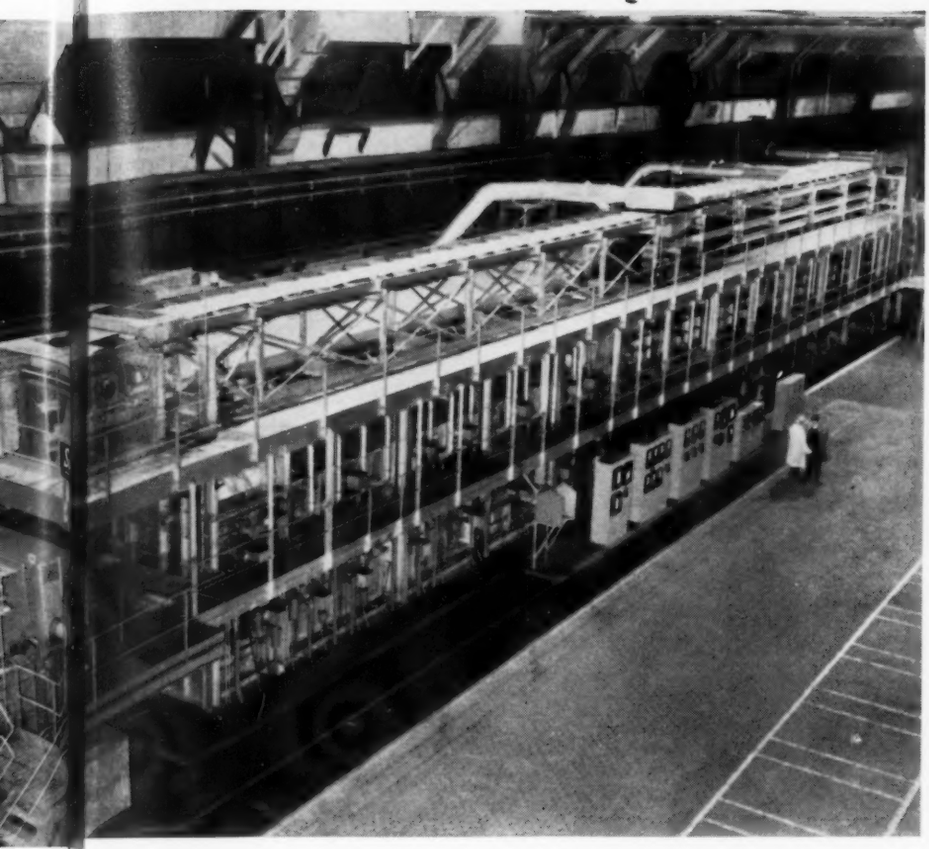
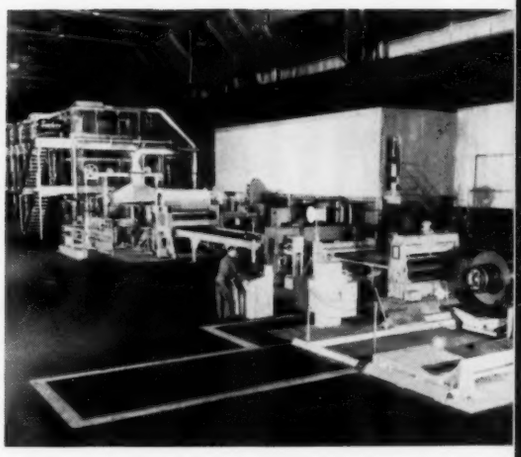
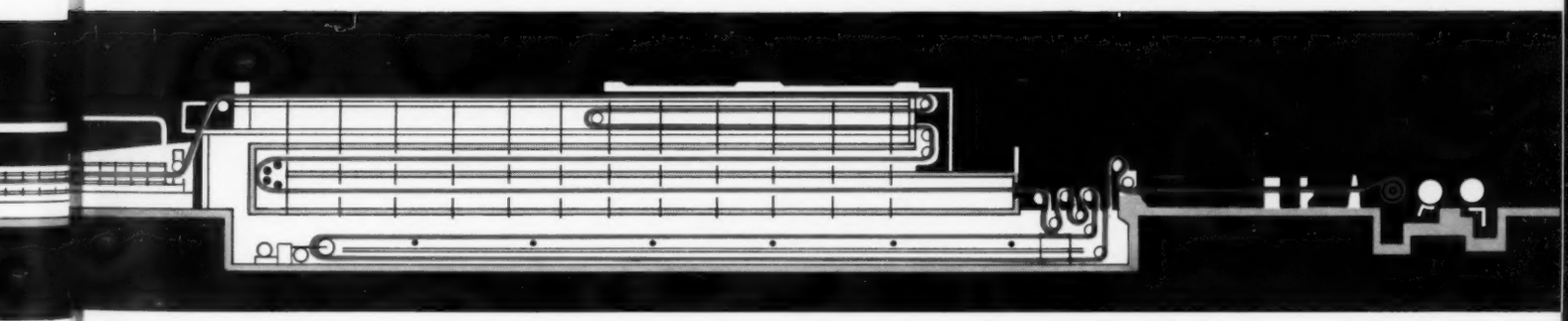


Rockwells in the low 40's are achieved consistently in this three-level normalizing furnace. Heating zone is on the lower furnace level; convection cooling in the middle; air blast cooling at the top. A horizontal "looper" is located underneath the furnace.



Payoff reel marks the entry of low carbon stock after cold rolling. Speeds of 150 fpm on 60″ wide strip are attained.



This complete new Surface normalizing line for vitreous enamel stock started paying off on its first day of operation. For example, its capacity of 30,000 lbs. an hour puts this mill forcefully into the market for deep draw quality strip. More than adding new selling power, this big line increased productivity per operator by an almost unbelievable amount.

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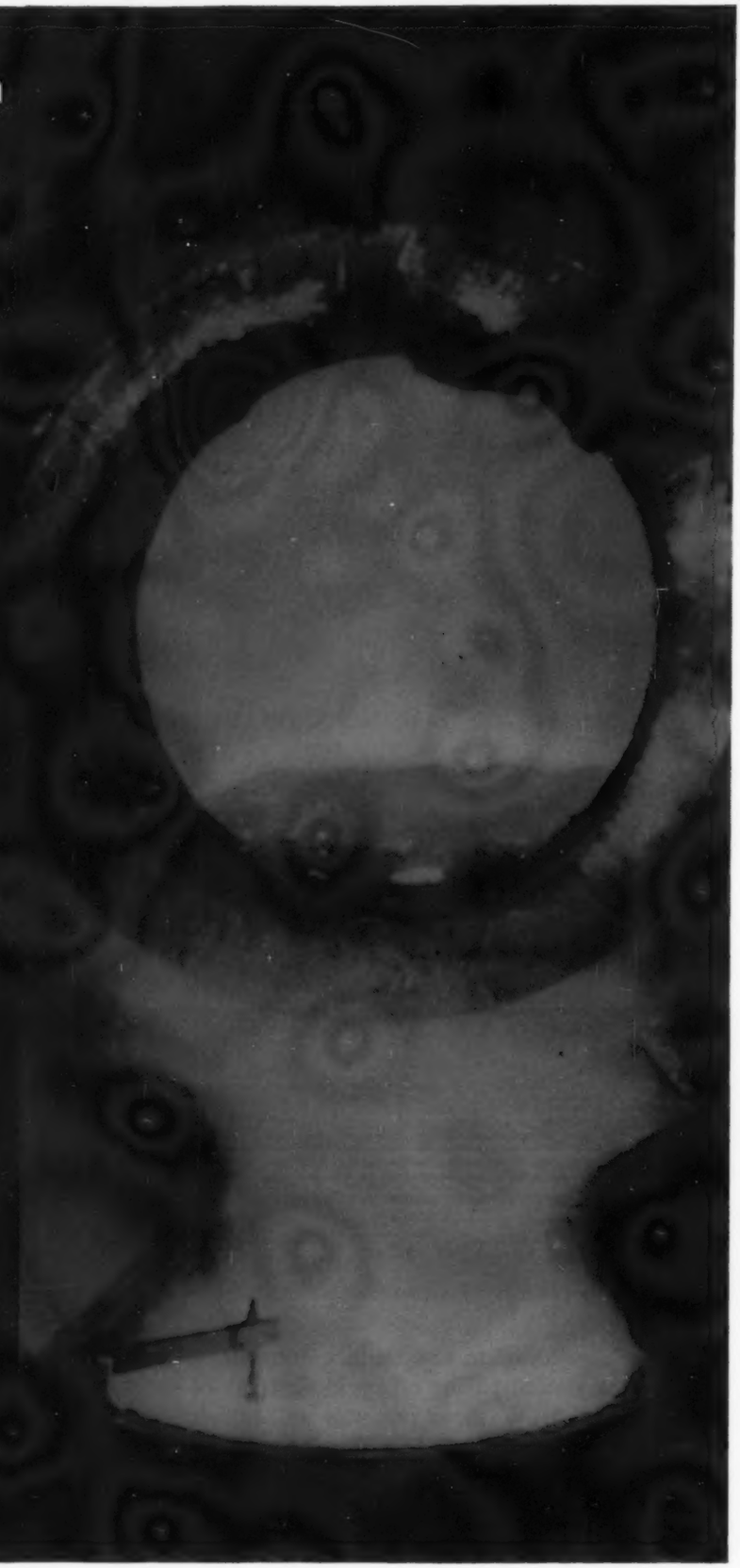

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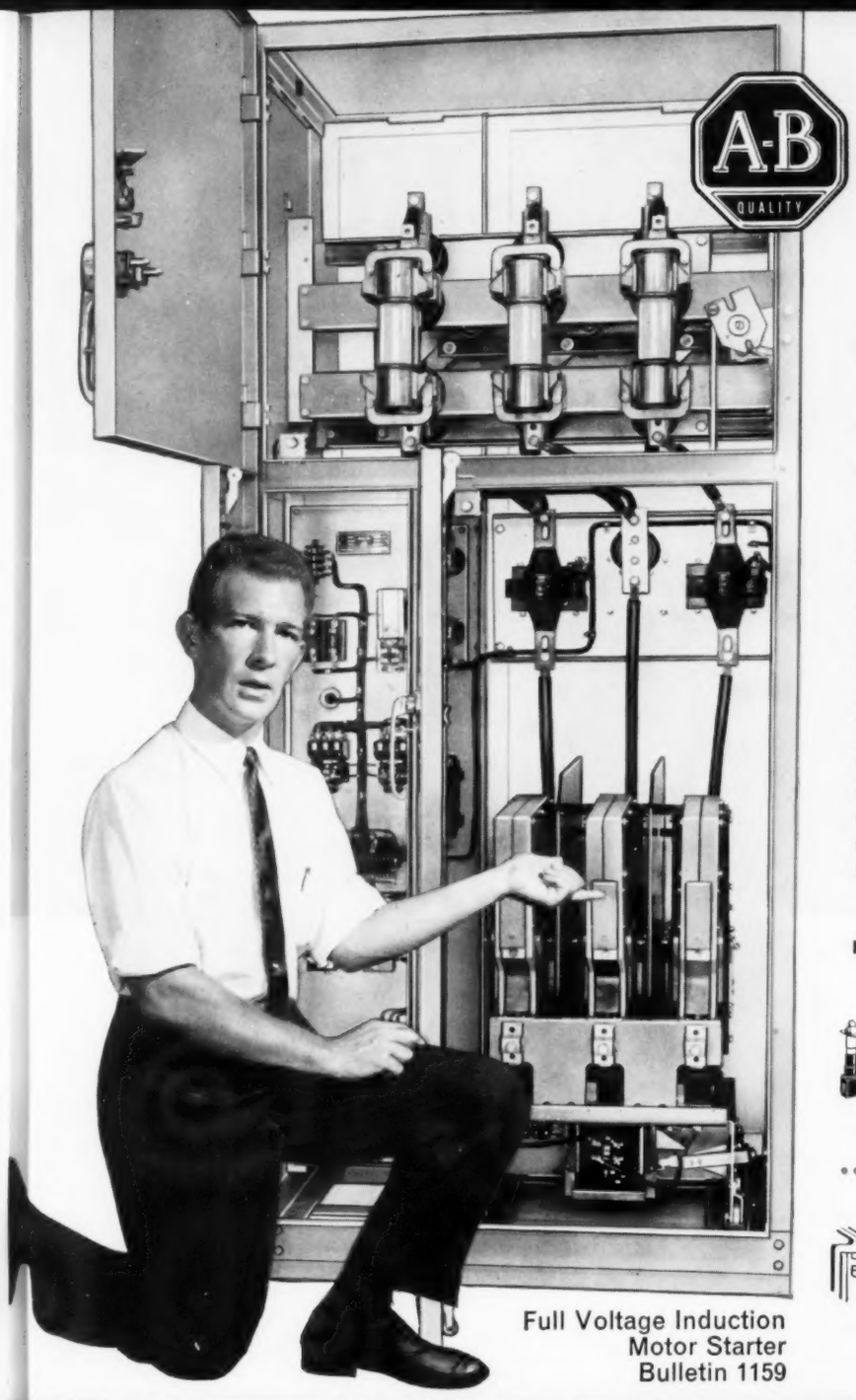

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Bulletin 1159

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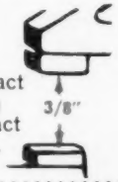

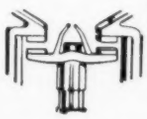

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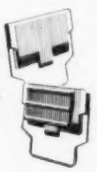
New blowout design, new arc chutes molded of arc resistant material.



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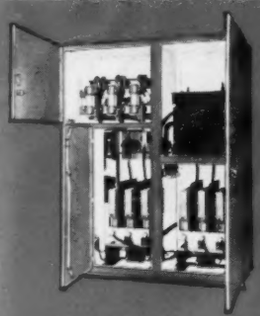
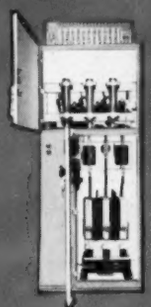
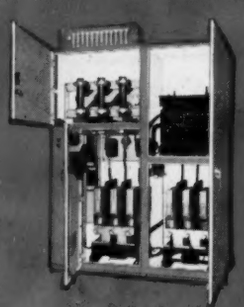


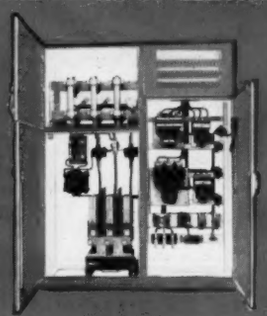
Reduced Voltage
Induction Motor Starter
Bulletin 1172



Full Voltage
Synchronous Motor Starter
Bulletin 966



Reduced Voltage
Synchronous Motor Starter
Bulletin 983



Wound Rotor Motor Starter
Bulletin 1180

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16-60-M

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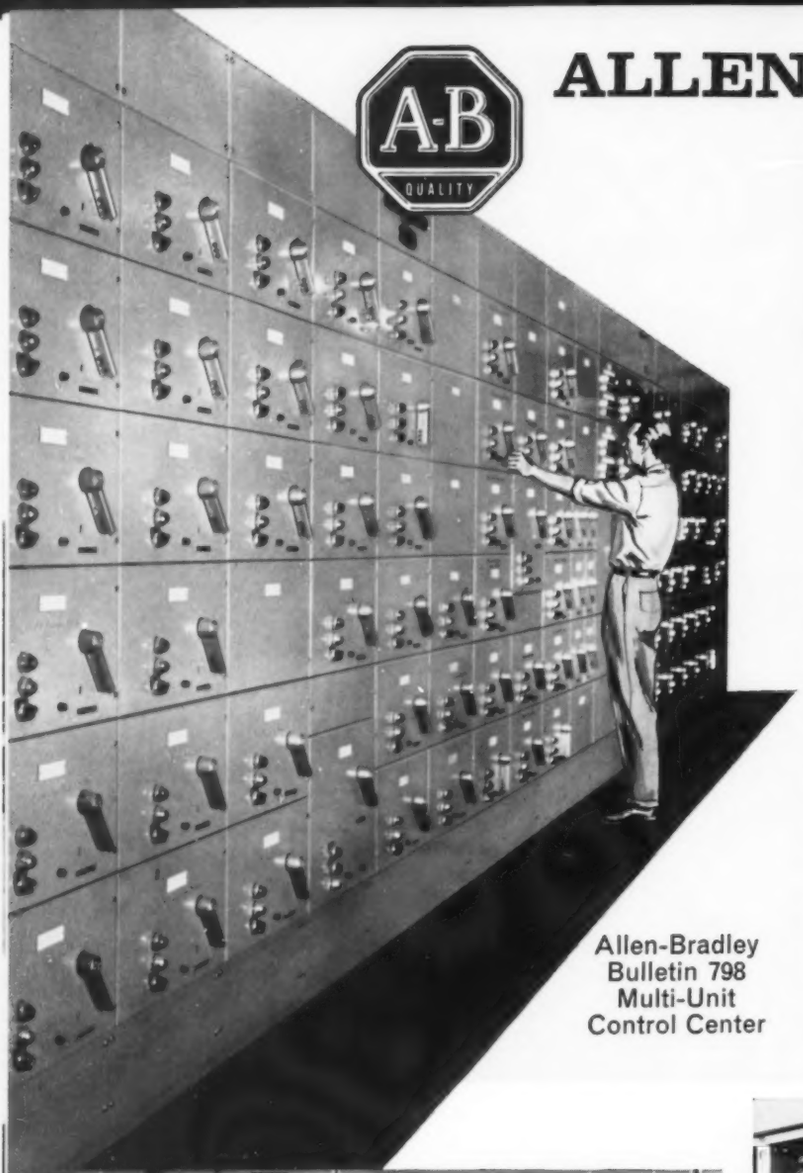
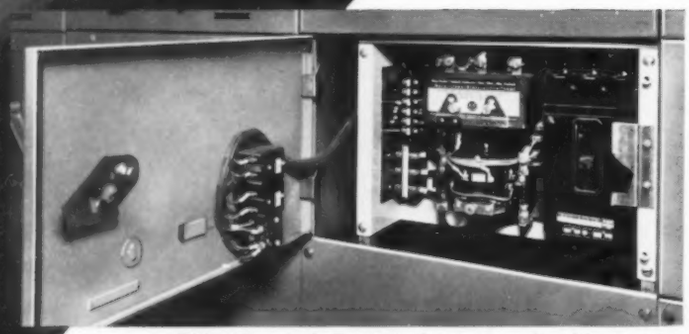
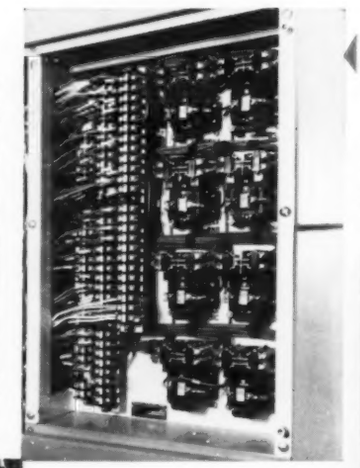


Allen-Bradley Bulletin 798 Multi-Unit Control Center

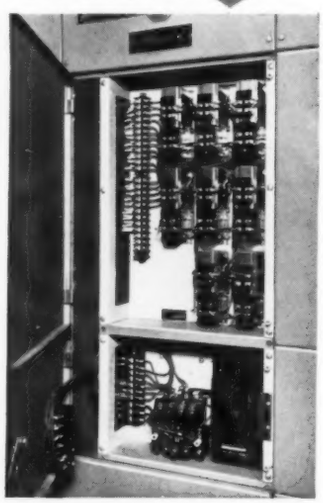


This shows A-B control center unit with popular A-B Bulletin 709 solenoid starter and circuit breaker.



This shows A-B Bulletin 700 control relays mounted in an A-B control center unit.

A-B control centers can be equipped with a wide variety of components. These Bulletin 849 timers are used on an automatic conveyor line.



This huge, 48-foot A-B control center houses 101 A-B Bulletin 709 solenoid motor starters. It is designed to permit an addition containing 50 more Bulletin 709 starters.

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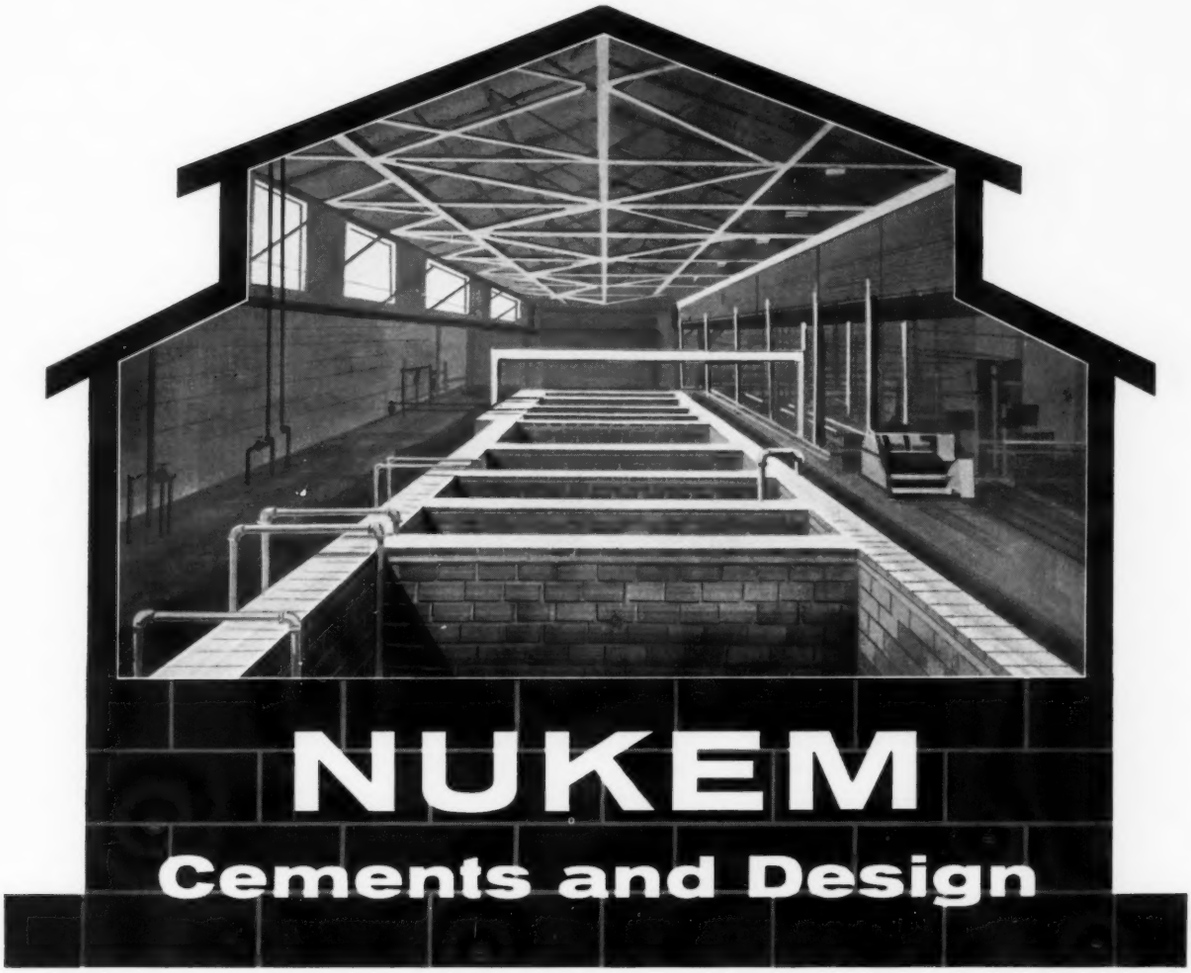
16-50-M



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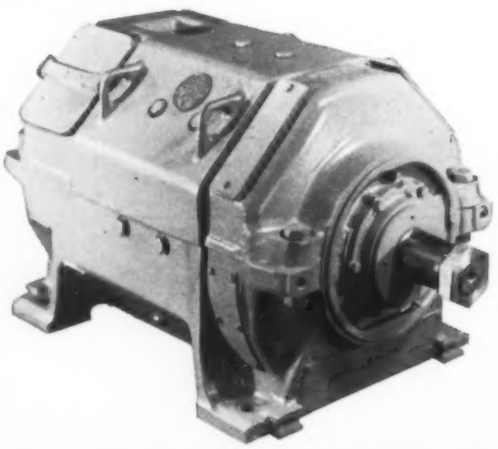
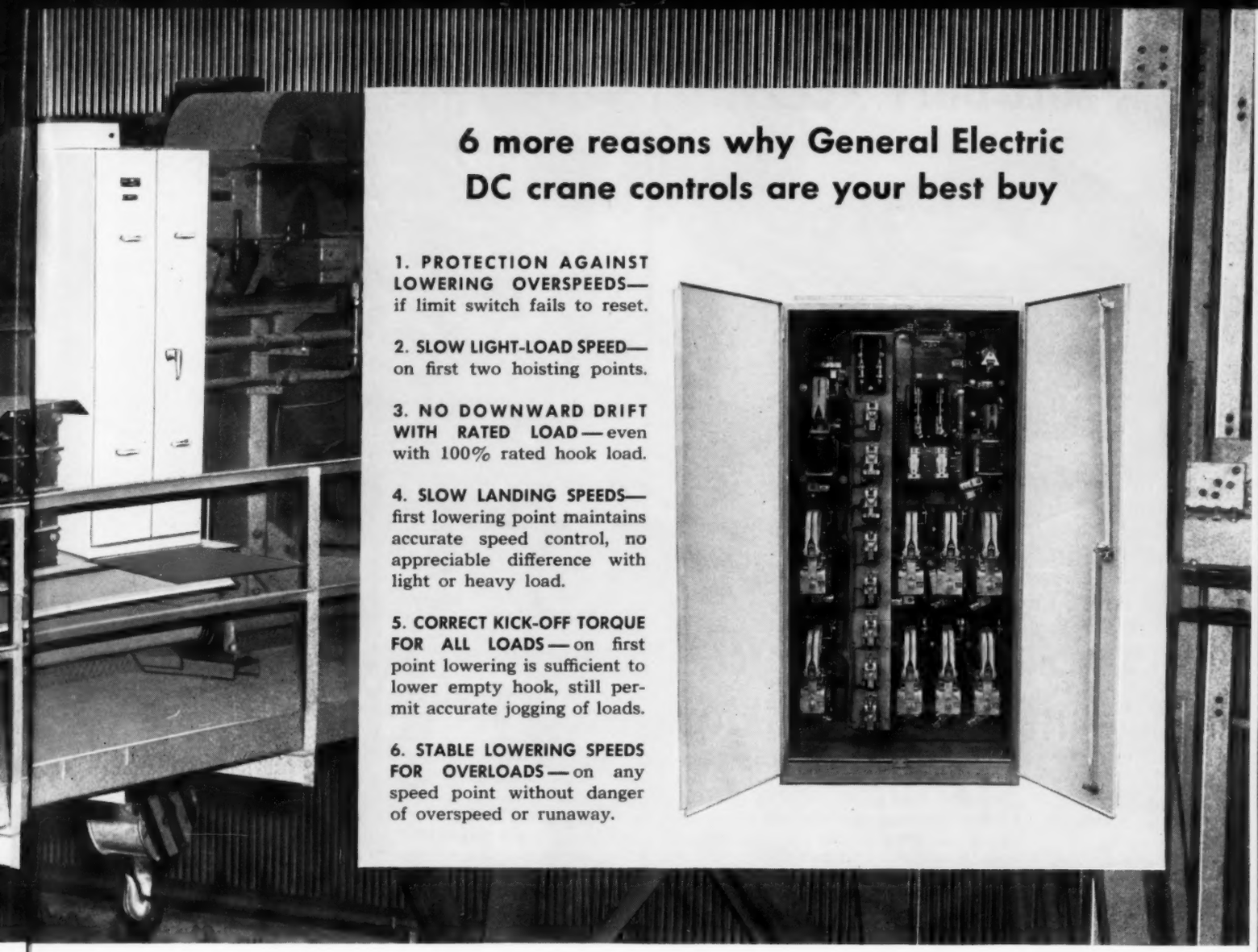


The General Electric MD-600 totally-enclosed armored motor is built for the heavy-duty handling requirements of steel mills. When used in combination with General Electric d-c crane control, you get outstanding performance, minimized maintenance, and your crane-drive lasts longer. The MD-600 motor accelerates heavy loads quickly, handles heavier long-time overloads, and withstands frequent heavy-duty cycles. Maintenance is simplified by the split frame which swings open almost 180 degrees to allow the armature to be lifted straight out. The MD-600's heavy cast-steel frame is sturdy—it's designed to withstand the most severe shock. Since its introduction in 1947, the MD-600 motor has earned its reputation as the sturdiest, most versatile mill motor available.



6 more reasons why General Electric DC crane controls are your best buy

1. PROTECTION AGAINST LOWERING OVERSPEEDS—if limit switch fails to reset.

2. SLOW LIGHT-LOAD SPEED—on first two hoisting points.

3. NO DOWNWARD DRIFT WITH RATED LOAD—even with 100% rated hook load.

4. SLOW LANDING SPEEDS—first lowering point maintains accurate speed control, no appreciable difference with light or heavy load.

5. CORRECT KICK-OFF TORQUE FOR ALL LOADS—on first point lowering is sufficient to lower empty hook, still permit accurate jogging of loads.

6. STABLE LOWERING SPEEDS FOR OVERLOADS—on any speed point without danger of overspeed or runaway.

floor-space requirements 50 percent

General Electric front-connected d-c crane control —introduced in 1957—makes back aisles unnecessary . . . cuts floor space needs by one-half. The modern design—in a smaller cabinet—allows installation on a smaller bridge, permitting closer hook approach to the ends of your building. The control is safer, lasts longer, and needs only minimum maintenance.

General Electric d-c crane control is performing dependably on many heavy-duty jobs—ladle cranes, soaking pits, skullcrackers, and scrap and slab yards. Over 125 hoist controls utilizing this front-connected design are installed and operating reliably.

Check these important benefits of General Electric d-c crane control for the steel industry.

Less maintenance—Definite time acceleration and deceleration provide excellent commutation and motor operation of d-c cranes . . . reduce maintenance.

Greater personnel safety—All devices are serviced from the front . . . no need to work behind panel.

Fewer spare parts—D-c crane controls and mill-drive controls use same devices . . . fewer spares needed.

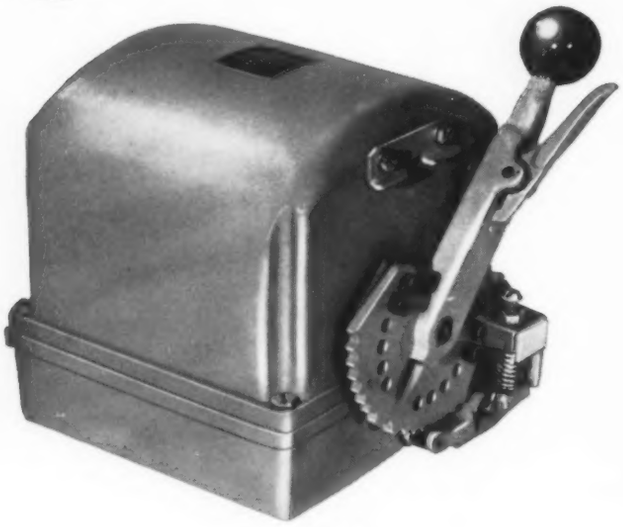
Longer equipment life—Heavy-duty unit bases and picture-frame construction provide long service.

For complete information on General Electric d-c crane control **and** MD-600 crane-drive motors, contact your nearest G-E Apparatus Sales Office or write Sect. 785-12, General Electric Co., Schenectady, N. Y.
Industry Control Dept., Salem, Virginia
Direct Current Motor and Generator Dept., Erie, Pa.

Progress Is Our Most Important Product

GENERAL ELECTRIC

MILL-DUTY ACCESSORIES



MASTER SWITCHES

Heavy-duty design offers long life, high reliability

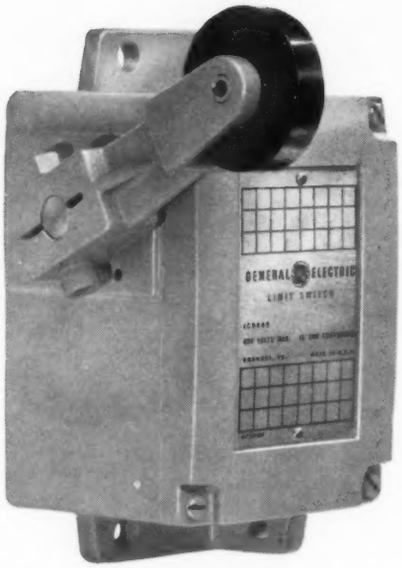
Self-lubricating phenolic cams—impregnated with graphite—keep General Electric master switches performing longer . . . even in the toughest conditions. Numerous mill installations show that these cams—coupled with steel cam followers—will operate millions of times without replacement.

Modern design of the G-E master switch permits quick modification—with a minimum of parts—to perform different sequences. And, cams can be interchanged without disassembling the switch. Offered in surface- or desk-mounted models, these switches are 25% smaller than other designs.

Check these "extra-value" features of General Electric master switches:

- **Entire switch unit** lifts out of enclosure for ease of wiring and mounting.
- **Pawl arrangement** allows for convenient adjustment to each operator's "feel."
- **Adjustable stops** give maximum of seven points in each direction, plus off.

Want more information? See your G-E Sales Engineer; or write Sect. 784-28, General Electric Co., Schenectady, N. Y. for Bulletin GEA-6706. *Industry Control Dept., Salem, Va.*



LEVER LIMIT SWITCHES

New adjustable cams permit fast, on-the-job adaptation

Here is a new lever-operated limit switch that lets you adapt it to the application . . . right on the job. You no longer need to predetermine circuit requirements before selecting a device. This means fast installation or quick adaptation when requirements change. A new system of adjustable cams on General Electric's lever limit switch makes this flexibility possible. A template—provided with every switch—guides changing the cams.

Lighter and more compact, General Electric limit switches are available for either two- or four-circuit operation . . . and, in a wide choice of enclosures.

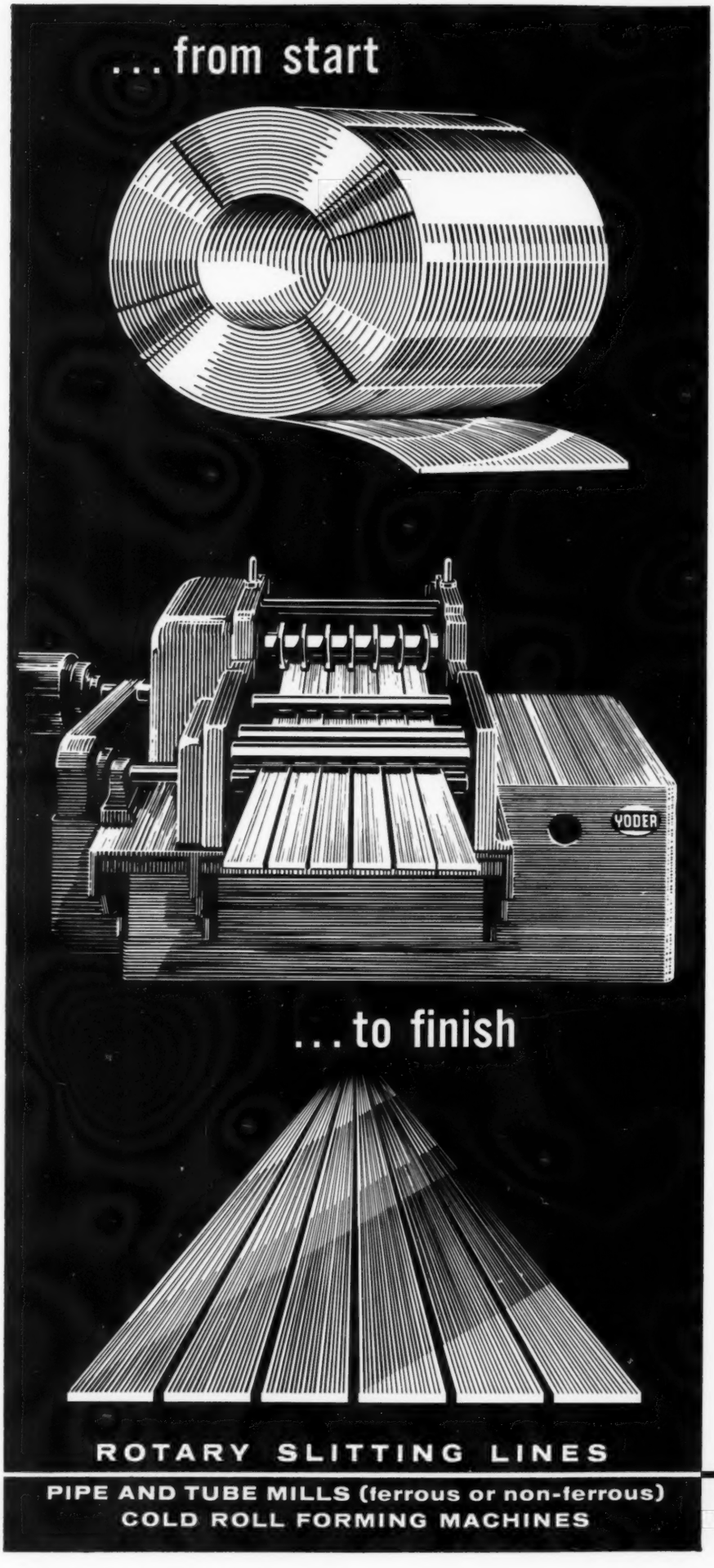
Consider these key features of the new General Electric lever limit switch:

- **Readily-accessible contact blocks** are of unit construction, easy to wire.
- **Variety of levers** offers wide selection to meet your specific application.
- **Starwheel** may be set for either maintained or spring-return operation.

For the complete story, see your General Electric Apparatus Sales Engineer, or write Section 784-28, Schenectady, N. Y. for Bulletin GEA-7203. *Industry Control Dept., Salem, Virginia.*

Progress Is Our Most Important Product

GENERAL ELECTRIC



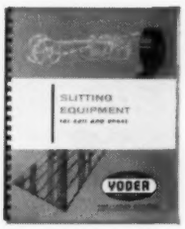
YODER ROTARY SLITTERS

If your slitting requirements call for coil widths from 12" to 60", in gauges from .015" to .250", the economy of purchasing Yoder Slitting Machinery can be yours. Operating a Yoder Slitting Line only one eight-hour shift per week, for example, could easily produce 35 tons of slit strands per week . . . or 1,820 tons every 52 weeks. At a slitting cost saving of only ½¢ per pound, the annual savings would amount to $18,200.

Additional savings can be realized through lowered inventory of mill-width coils—less waiting for delivery of special slit widths. Also, customer satisfaction will increase as you achieve faster completion and delivery of finished products.

At your request a Yoder sales engineer will study your plant operation to determine what equipment would most economically . . . and profitably . . . serve you, whether it be standard components or a completely specialized and engineered line.

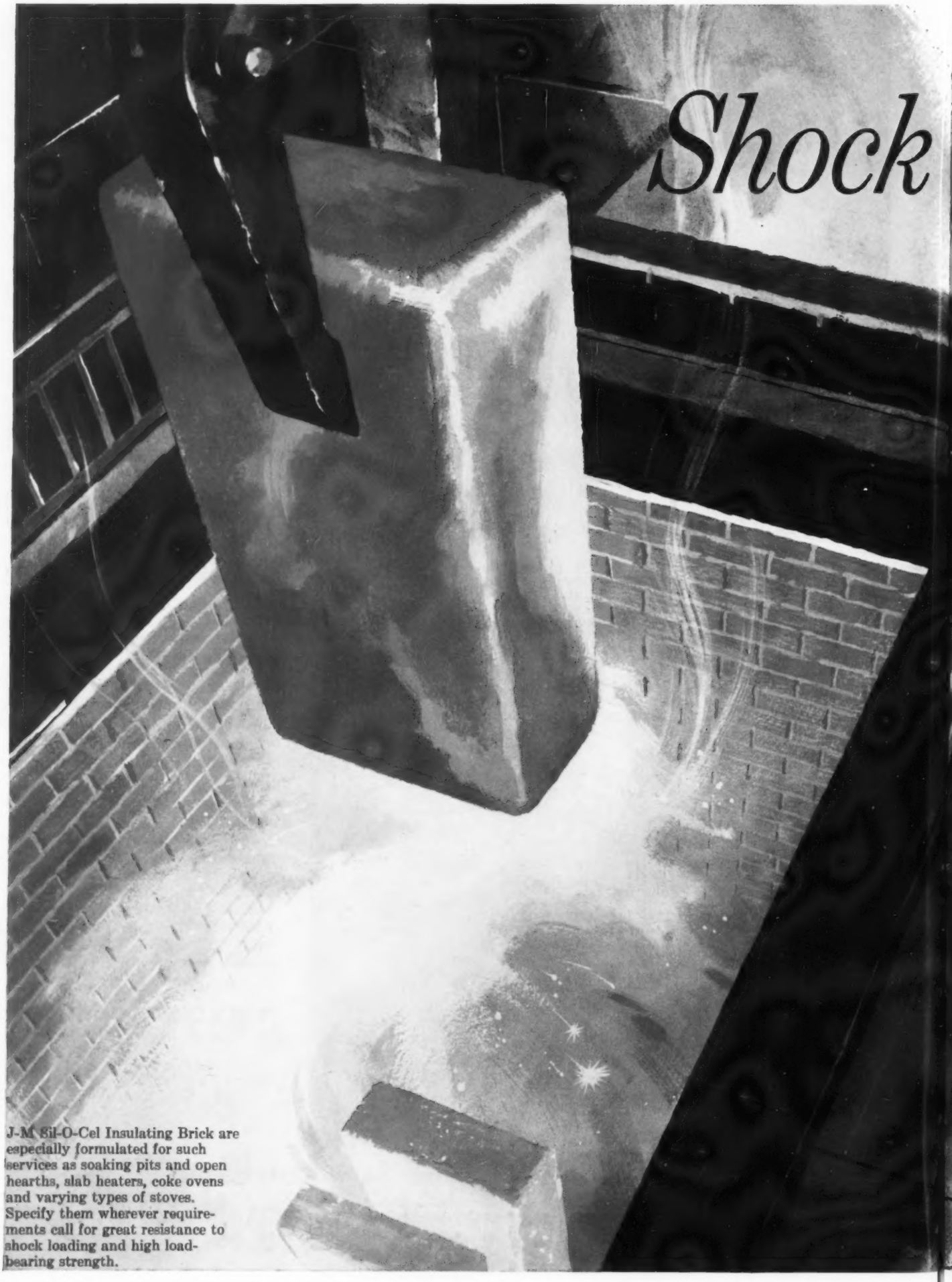
Send for this illustrated text on slitting operations and equipment. It describes methods, time studies, operating cycles, material handling, and gives full specifications.



THE YODER COMPANY
5495 Walworth Ave. • Cleveland 2, Ohio

ROTARY SLITTING LINES
PIPE AND TUBE MILLS (ferrous or non-ferrous)
COLD ROLL FORMING MACHINES

ENGINEERING
YODER
MANUFACTURING



J-M Sil-O-Cel Insulating Brick are especially formulated for such services as soaking pits and open hearths, slab heaters, coke ovens and varying types of stoves. Specify them wherever requirements call for great resistance to shock loading and high load-bearing strength.

loads...and crushing weight

call for Johns-Manville Sil-O-Cel Insulating Brick!

Hot blast stove walls, open hearths, soaking pit bottoms—the unexcelled performance of J-M Sil-O-Cel® brick in rugged services like these explains their wide acceptance. Today, they are used as back-up insulation by virtually every major equipment builder.

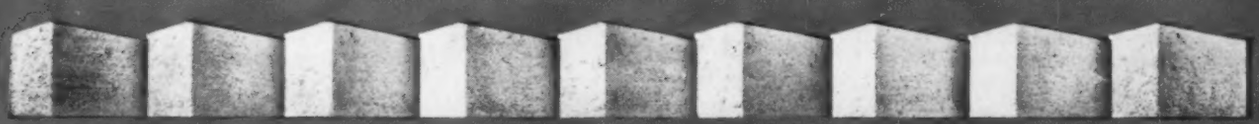
Made of heat-resistant diatomaceous silica, Sil-O-Cel Insulating Brick are produced in three load-bearing types: Sil-O-Cel *Super* (to 2500F) and Sil-O-Cel *C-22* (to 2000F) for peak performance and long life under extremes of heat, weight and shock. Sil-O-Cel *16L* combines performance and economy for lower temperatures to 1600F.

To bring you the right brick for your needs, Johns-Manville *also* offers six Insulating Fire Brick types. This wide selection of Insulating Fire Brick lets you choose the *one* brick that gives you the most favorable combination of temperature resistance, strength, conductivity, density and cost.

Write today for your copy of IN-115A, 8-page booklet on Johns-Manville Insulating Fire Brick. It gives complete physical and thermal properties of each type, along with sizes and shapes available. Address Johns-Manville, Box 14, New York 16, New York. In Canada, Port Credit, Ontario.

JOHNS-MANVILLE JOHNS-MANVILLE JM PRODUCTS

THE INDUSTRY'S MOST COMPLETE LINE OF INSULATING FIRE BRICK

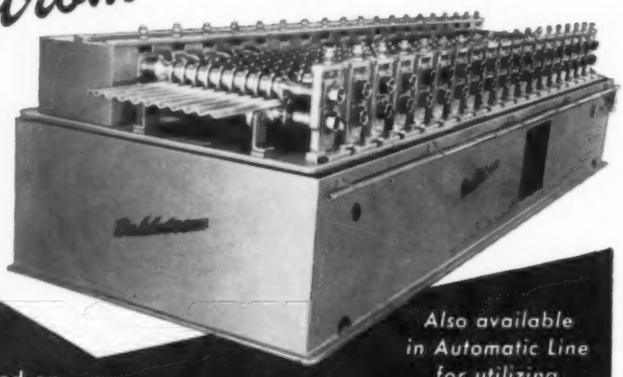


JM-3000	JM-28	JM-26	JM-23	JM-20	JM-1620	Sil-O-Cel® Super	Sil-O-Cel C-22	Sil-O-Cel 16L
service to 3000F	service to 2800F	service to 2600F	service to 2300F	service to 2000F	to 1600F exposed; to 2000F back-up	to 2500F back-up	to 2000F back-up	to 1600F exposed or back-up

CORRUGATE SHEETS with a

Dahlstrom

ROLL FORMING MACHINE



FEATURING:

- All welded construction.
- Roll shafts mounted on anti-friction bearings.

Also available in Automatic Line for utilizing coil stock.

Major Building Products Manufacturers use this setup for corrugating 20 through 28 gauge galvanized steel, plain and embossed aluminum.

Requires only vertical adjustment for gauge range. Roller die tooling available for various depths. Excellent control of coverage and depth. No length restrictions.

Other gauge ranges also available. Send complete detailed specifications for quotation.

Dahlstrom **MACHINE WORKS** INCORPORATED

4226 W. Belmont Ave., Chicago 41, Ill. Phone: SPring 7-3670

•

DAHLSTROM also manufcctures a complete line of equipment for fabricating Coil and Sheet Metal.

•

- **ROLL FORMING MACHINES**
- **SLIDING DIE-TYPE CUT-OFF PRESSES**
- **COIL REELS**
- **COIL LIFTS**
- **ROLL STRAIGHTENERS**
- **PRESS FEED EQUIPMENT**
- **DECOILING AND SHEARING LINES**

•

THOUSANDS OF CUTS THROUGH STEEL RODS WITHOUT A BREAKDOWN!

Typical of the reports that come from rod and wire mills everywhere. Proof-positive that Porter has practically eliminated down-time for repairs. To cut maintenance costs and speed your cutting operations, it will pay you to get all the facts on the Porter one-hose HYDRAULIC ROD and BAR CUTTERS.

CUTTER BLADES THAT ARE REALLY RUGGED

Blades are longer . . . have *more* bearing surfaces for rigid alignment. No side thrust to cause breakage. Filtered air taken into the cylinder is forced out around the movable blade on each cut — eliminates danger of dirt reaching bearing surfaces causing oil leakage and wear.

FOOL-PROOF HYDRAULIC SYSTEM

Just-one-hose design cuts replacement costs in half. Finger-tip control of cutting action! Reservoir-type 40 micron oil filter is easy to change. Adjustable relief valve saves wear and tear by providing the correct pressure for any cutting job. 12-Volt control circuit provides for operator safety.

WRITE TODAY FOR ALL THE FACTS

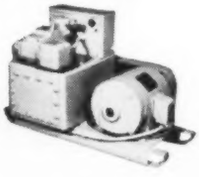
Let us show you how any combination of 3 cutter-heads for capacities up to 1⅜" steel rods and 5 hydraulic power units can be matched to your exact requirements. Or we can design special heads for punching, crimping, heading, or forming. Write today for an on-the-job demonstration or a copy of our Rod and Bar Cutter Catalog.

PORTER

HKP®

ONE HOSE HYDRAULIC

ROD & BAR CUTTER

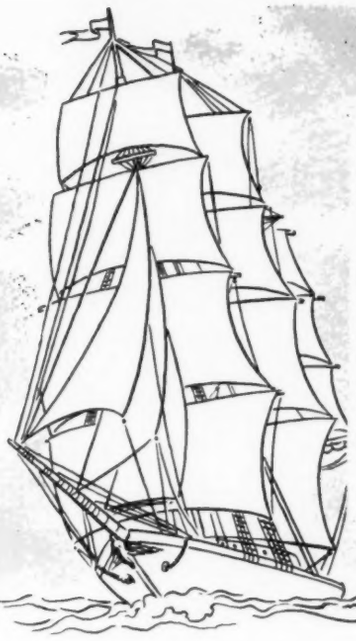


H. K. PORTER, INC.,

Somerville 43, Mass.

Why Rust-Oleum is different—

and what this difference, backed by 35 years of industry proof, means to you!



A Sea Captain developed it . . . Industry proved it!

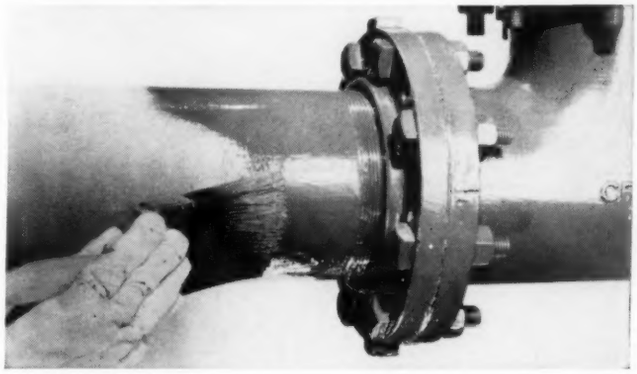
The original Rust-Oleum formula was developed nearly fifty years ago by Sea Captain Robert Fergusson, who became intrigued with the rust-stopping qualities of fish oil early in his career. Creating a *special treatment* for the fish oil, he used the *specially-processed fish oil* as the vehicle in combination with fine rust-inhibiting pigments. The result? A coating that actually *stopped rust* when applied directly over sound rusted surfaces, after scraping and wirebrushing to remove rust scale and loose rust. Possible, because the *specially-processed* fish oil penetrated the rust to bare metal. This was the birth of Rust-Oleum's *exclusive* 769 Damp-Proof Red Primer.

PROVED THROUGHOUT INDUSTRY FOR OVER 35 YEARS

Today, Rust-Oleum in its many systems and colors, has been proved throughout industry for over thirty-five years. This proof by leading industrial users is your assurance of savings in time, money, and metal. Economies made possible by the fact that Rust-Oleum 769 Damp-Proof Red Primer goes right over the sound rusted metal—usually eliminating costly surface preparations. And Rust-Oleum, in its various systems, resists rain, sun, fumes, heat, weathering, chemicals, etc., for lasting beauty over the years.

RUST-OLEUM NEW COLOR HORIZONS SYSTEM

The Rust-Oleum New Color Horizons System introduces a new coating concept to industry. It combines four important factors: (1) the ability to stop rust, (2) smart, modern color harmony, (3) the durability to last and last, (4) ease of application that saves time, money, and metal. See how this system can bring lasting beauty to your plant, machinery, equipment, pipes, tanks, structural steel, fences, etc. Write for complete information or contact your nearby Rust-Oleum Industrial Distributor. He maintains complete stocks for prompt service.



RUST-OLEUM®

There are imitations, but only *one* Rust-Oleum. It is distinctive as your own fingerprint.

STOPS RUST!®

ATTACH TO YOUR LETTERHEAD

Rust-Oleum Corporation

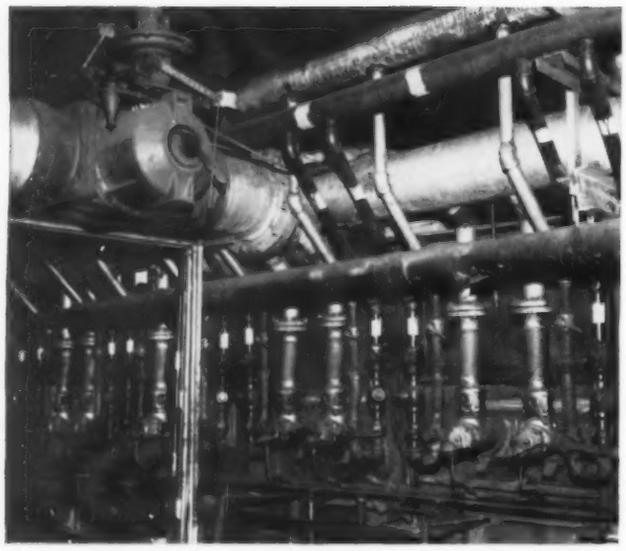
2650 Oakton St., Evanston, Illinois

Please send me the following at no cost or obligation:

- ☐ New Color Horizons Systems Catalog featuring 110 actual color standards and 69 photo applications.
- ☐ Free test sample of Rust-Oleum 769 Damp-Proof Red Primer to be applied over sound rusted surface.
- ☐ Results of radioactive tracing study on Rust-Oleum fish oil penetration.

ATLAS STEELS

Maintenance Records Dictate: Use North American Burners



Atlas Steels Limited's Utilities Engineer says: "Maintenance is confined to the water-cooled rolls and the refractory. This furnace has proven that special and complex heating equipment is not required to obtain very high thermal releases in a small space."

This high thermal head furnace heats 2¼"x 20" stainless steel slabs for one-step reduction to ⅛" in a planetary rolling mill. Slabs pass through the 108 ft., 7 zone furnace in only 14 minutes including soak time.

The elliptical combustion chamber is fired tangentially with 2 rows of North American Series 221 Dual-Fuel Burners. N. A. Adjustable Port Valves and #600 Air Motors Control the input.

You too can save money—specify North American burners, blowers, and controls—they're built for high production without high maintenance.

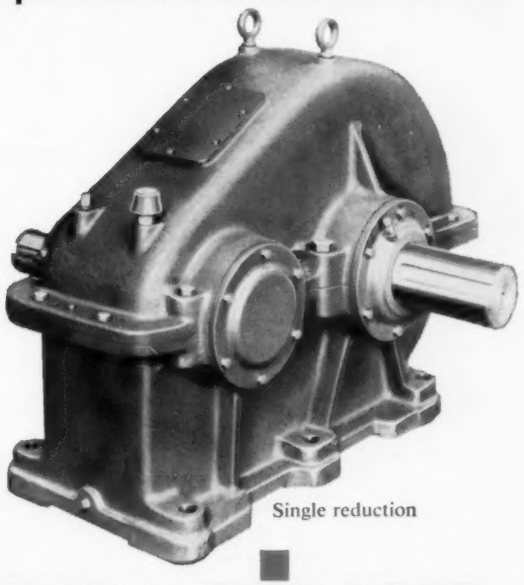
For engineering information,
call your nearby North American Combustion Engineer or write to ▼

NORTH AMERICAN for COMBUSTION and Hydraulic Controls

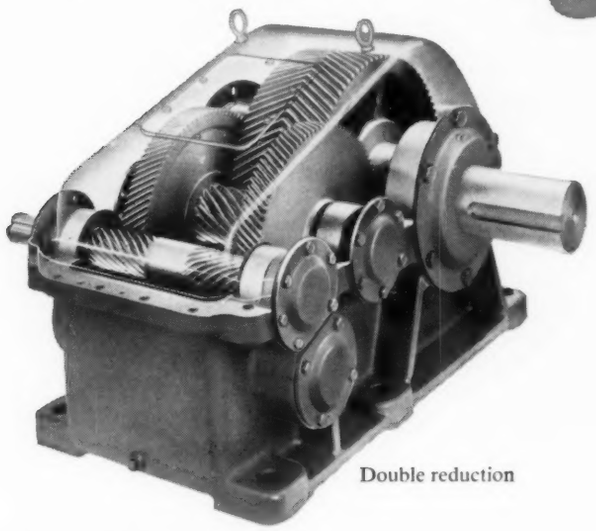
The North American Mfg. Co.
Cleveland 5, Ohio

NOW Link-Belt parallel shaft speed reducers offer

new design



Single reduction



Double reduction

new sizes

new ruggedness

Triple reduction

reduce drive costs by matching drive size to horsepower requirements with 35% more sizes

New design—Herringbone or double helical gears arranged in new "balanced" design permit high horsepower, high ratio reduction in a sturdy, compact housing.

New sizes—Now 18 sizes each of double and triple reduction units; 17 single. Drive selections closely match hp requirements, with a corresponding reduction in drive costs. Available to 2800 hp, ratios to 292:1.

New ruggedness—Rigid, ribbed housing keeps parts accurately and permanently aligned even under grueling operating conditions involving heavy shock loads, and temporary overloads.

For complete information call your nearby Link-Belt district sales office or authorized stock-carrying distributor. Ask for Book 2719.

OUTSTANDING FEATURES

- Grease-lubricated seals.
- Positive splash lubrication supplies ample flow of oil to all moving parts.
- High-capacity spherical roller bearings for maximum loading.
- Gears of hardened, precision alloy steel. Double helical or herringbone design.
- New, built-in backstop.
- Exceptional wearing qualities in accurately machined low-speed shafts of heat-treated carbon steel; intermediate shafts of chrome-molybdenum steel.
- Cast iron housing maintains permanent, accurate alignment of all parts.

LINK-BELT

SPEED REDUCERS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,364

Where **ACME STEEL** *Has Placed Complete Reliance on the Unique Gas-Cleaning "Know-How" of*

WESTERN PRECIPITATION

Virtually every major steel company across the nation has Western Precipitation equipment of one type or another handling gas cleaning operations from various types of steel-making applications.

At Acme, For Example . . .

Basic Oxygen Converters

A DRY-TYPE PRECIPITATOR, known as a Western Precipitation Cottrell Unit, is installed on the Basic Oxygen Converters to provide final clean-up of gases before they are discharged to atmosphere.

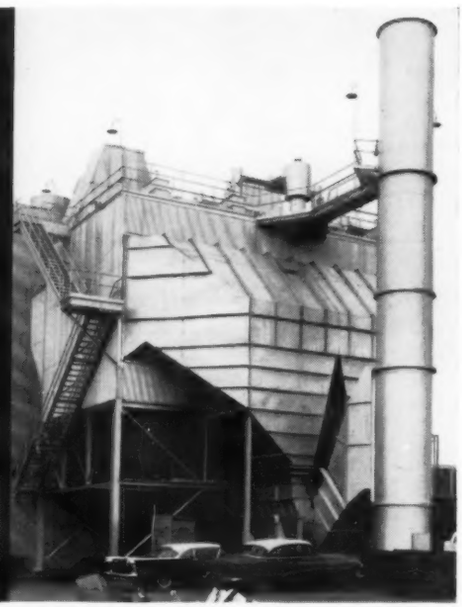
Hot Blast Cupolas

"MULTICLONE" COLLECTORS, Western Precipitation's highly efficient small-tube collectors, are used for first stage cleaning of cupola gases.

Hot Blast Cupolas

A WET-FILM PRECIPITATOR, also known as a Western Precipitation "Pipe Type" unit, provides final clean-up of the cupola gases before they are fired in a high efficiency gas-air hot blast heat exchanger.

Western Precipitation "Wet Type" Precipitator



Western Precipitation "Dry Type" Precipitator

Wherever There's A Gas-Cleaning Problem, there's a type of Western Precipitation unit to fit the job — for Western Precipitation is the ONE organization that designs, engineers and installs ALL 7 types of gas cleaning equipment . . . Precipitator, Cyclone, Combination Precipitator-Cyclone, Jet-Cleaned Filter, Hi-Temp Filter, Deep-Bath Scrubber and Jet-Whirl Scrubber.

This unusually broad range of equipment — coupled with Western Precipitation's wide experience in dust and fume control — permits a completely unbiased recommendation on the type of unit best suited for *your particular* operations. For the optimum in dust and fume control you can rely on Western Precipitation "know-how".

***Our Nearest Office** will gladly supply details on how we can simplify your gas cleaning problems. A letter or phone call places this experience at your service, without obligation!*

WESTERN PRECIPITATION
DIVISION OF JOY MANUFACTURING COMPANY
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Cottrell Precipitators	Multiclone Dust Collectors	Therm-O-Flex Hi-Temp Filters	Dualaire Reverse-Jet Filters	Turbulaire-Doyle Scrubbers	Joy Microdyne Scrubbers	Combination Units	Holo-Flite Processors	Hi-Turbiant Heaters

Foreign Digests

Complete translations from which these condensations were prepared are available from Henry Brutcher, P.O. Box 157, Altadena, Calif., to whom all correspondence should be addressed.

"WORKS METHOD FOR DETERMINATION OF REDUCIBILITY OF SINTER FOR BLAST FURNACE"

by T. A. KRAMNIK, Dzerzhinskii Works, (Translation No. 4731 from Stal', Supplement—Blast Furnace Production, vol. 18, 1958, pp. 16–25)

△ DESPITE the difficulties involved in determining reducibility and its relative character, information on the metallurgical properties of agglomerate, specifically sinter, is of great value.

According to available data, the reducibility of agglomerate is governed by its chemico-mineralogical composition, and the degree of fusion and porosity.

SUMMARY

1. In a standard rapid method for the determination of the reducibility of agglomerate it is sufficient to create and maintain conditions of reduction which will indicate the relevant properties of the agglomerate. The apparatus must be simple and reliable.

2. The method adopted at MMK using synthetic blast furnace gas in a horizontal furnace required four to five hours; the apparatus was cumbersome and the method did not fulfill the necesssry requirements for a rapid works method.

3. A method has been evolved at the Dzerzhinskii works which complies with these conditions. It comprises reduction with hydrogen in a vertical furnace fitted with thermocouples; the apparatus is based on a design by Prof. A. N. Pokhvisnev. The sample weight can, if necessary, be increased to 100 g, and the determination takes 30 to 40 min. The whole installation is very simple and is suitable for any works laboratory.

"NEW DESULPHURIZING PROCESSES FOR PIG IRON OUTSIDE THE BLAST FURNACE"

by S. K. SOBOLEV, G. N. OIKS, V. F. ISUPOV, and V. M. SMETANIN, Moscow Steel Institute. (Translation No. 4858 from Izvest. Vuz-Chern. Met., Nov. 1959, No. 11)

△ Report on two new developments in the blowing of a desulphurizing agent (for example, lime) through liquid pig iron, intended to eliminate the shortcomings of the present method of blowing a suspension of lime plus aluminum through hot metal held in a ladle.

Ejector method—General arrangement for incorporating the desulphurizer by the ejector effect of the hot metal, thus insuring intimate contact; applicability of ejector method to the pouring of hot metal into or out of a mixer. Amount of sulphur removed and consumption of desulphurizer.

Vortex method—Design of device for imparting to the hot metal a vortex motion with desulphurizer being fed into center of vortex. Results when desulphurizer is fed as suspension in air or without a carrier gas.

The vortex method insures intimate contact between desulphurizing agent and the liquid iron. When using 1.5 to 2.8 per cent lime with an addition of 0.03 to 0.06 per cent aluminum (on the weight of the iron) a sulphur removal of from 30 to 60 per cent is reached. The use of this desulphurizing mix in suspension in air proved more effective than use without a carrier gas.

The possibility of carrying out external desulphurization of liquid blast furnace iron by the ejector method has been demonstrated.

"SAMPLING OF COMBUSTION PRODUCTS FROM COKE OVEN HEATING FLUES"

by V. G. PROTOD'YAKONOV and A. P. BORODIKHIN, Kuznetsk Iron and Steel Works. (Translation No. 4891 from Koks i Khimiya, Vol. 29, 1959, No. 6)

△ The thermotechnical team at the by-product coke plant laboratory of the Kuznetsk Iron & Steel plant are using a gas-sampling tube which permits the taking of an unlimited number of samples of combustion products from coke-oven heating flues.

A number of porcelain tubes wound with asbestos cord are inserted, one after the other, into a stainless steel tube. To preclude contact between the combustion products and unprotected metal, the entry end of the gas-sampling tube is coated with powdered fireclay and waterglass. The organic part of the

asbestos burns off after a 30-minute exposure to one of the heating flues, the compound fuses and covers the bare portions of the metal with a protective layer. After that, the tube is ready for use.

Samples are taken by means of a rubber ball. For this reason, it is important that gas temperature is not higher than 176 F. To this end, the exit opening of the gas-sampling tube is provided with a stainless steel cooling unit which permits the temperature of the sampled combustion products to be lowered.

OTHER AVAILABLE TRANSLATIONS

"Temperature Nonuniformity of Steel Baths in Arc Furnaces," by V. M. Vinogradov, Stal', vol. 17, 1957, No. 3. Inaccurate determination of average temperature of steel bath in arc furnace resulting in considerable variation in metal temperature in ladle, and hence often in a substandard product. Study of actual temperature distribution in a basic arc furnace (5 and 15-ton capacity) producing 1 per cent C, 1.5 per cent Cr steel and high-carbon, high-chromium steel. Temperature measuring technique, points of measurement and measuring results across the surface and in depth. Fluctuations of steel temperature in the ladle in 30 to 45 per cent of the heats ranged between 235 and 260 F. (Translation No. 4195)

"Use of Oxygen in Production of Electric Steel," by F. P. Edneral, Moscow Steel Institute. "Primenenie Kisloroda v Metallurgii" (Use of Oxygen in Metallurgy). Published by Metallurgizdat, Moscow, 1957. Special features of production of low-carbon stainless steel, especially 18-8 Ti steel, in medium-capacity arc furnaces, with injection of oxygen. Melting practices at several major Russian works: data on charging materials, yields, power consumption, oxygen and lance consumptions, refractories wear, etc. Production of alloy constructional and tool steels, and of carbon steels. Possibilities opened up by use of oxygen in electric furnace. (Translation No. 4460)

"New Results in the Sintering of Iron Ores with Blast Furnace Gas as Supplementary Fuel," by J. Holzhey, Neue Hutte, vol. 5, 1960, No. 3. Report on a new sintering practice that compensates for a large portion of the heat deficiency commonly encountered at the start of the sintering process. Conventional ore sintering with special reference to temperature conditions at various depths of bed and their effect on the progress of sintering process. Quality of sinter as affected by sintering rate and temperature. Shortcomings of classic sintering process and possibilities of remedying them. Use of blast furnace gas as supplementary fuel; merits of the two methods of using this gas for sintering. Savings on coke (50 per cent); degree of utilization of top gas; increase in sinter strength: (12 per cent); drop in sinter output: (8 per cent). Effect of addition of top gas upon temperature distribution in the mix and on sintering rate. Comparison of heat balances in sintering with and without supplementary gas. Over-all heat saving by proposed practice: 13 per cent. (Translation No. 4831)

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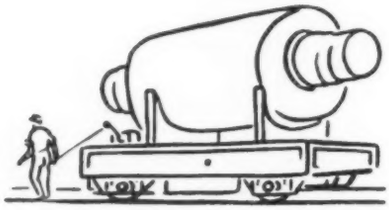
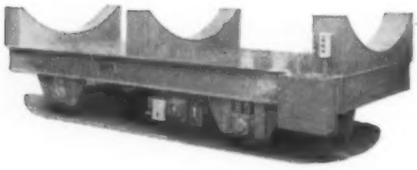
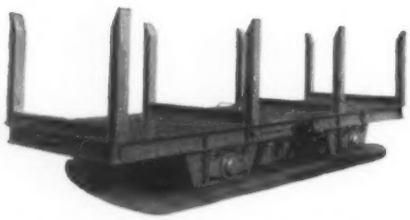
efficiency





20-Ton Storage Battery with Cradle for Pipe



40-Ton Safety-Type Walk-Along with Stake Bed

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SAFETY-TYPE TRANSFERS

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- *SAFE — because car stops when operator releases lever.*

Atlas transfer equipment is designed for your specific load and production needs. Optional power includes Storage Battery (Walk-Along or Rider-Type) • Gas-Electric • Diesel-Electric • Cable Reel AC • Cable Reel DC • Cable Reel AC With Fluid Coupling • also remotely controlled cars without trailing cable.

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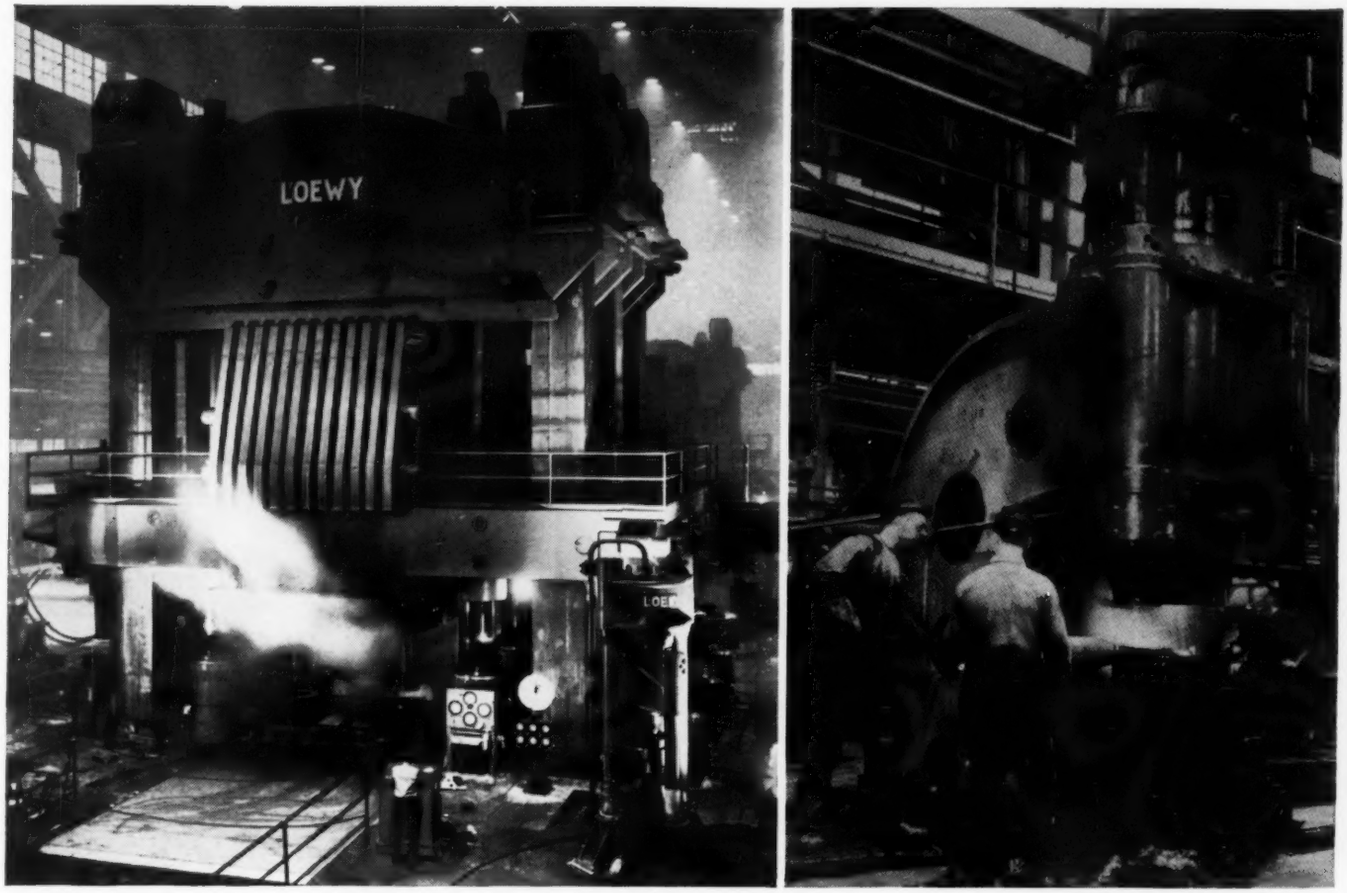

These two Loewy presses graphically illustrate B-L-H's ability to meet your forging press needs, regardless of press size.

WHAT DO THE CRITICS HAVE TO SAY ABOUT B-L-H LOEWY FORGING PRESSES?

We're talking about the severest, most discriminating critics we know—our customers. With a substantial capital investment involved, they unhesitatingly demand that Loewy presses perform superbly.

Here are just two examples of our customers' judgments. A leading alloy steel manufacturer in Pennsylvania spotlights our 2000-ton forging press in his full-page advertisement in national magazines.

The copy states that the Loewy press improves the production of his quality tool steels and that it is ". . . speeding delivery of more-uniform large forgings" in regular production and is ". . . ready to meet special custom forging demands."

Another well-known steelmaker stimulates his sales by means of two brochures which focus on his Loewy press. He testifies that "this fast-acting 2000-ton hydraulic forging press imparts to special steels internal qualities never before achieved."

Similar statements about our equipment are made very frequently. Certainly one of the most remarkable is in a report to the U.S. Air Force which foresees savings of approximately $13,000,000 on a single model of a jet fighter, thanks to the economical production of parts on the famous 50,000-ton Loewy forging press.

B-L-H builds presses for free forging, open die forging, and closed die forging, for hot and cold working of all kinds of metals—ferrous and nonferrous, rare, nuclear and exotic. These machines are available in all capacities from *five hundred to fifty thousand* tons or more. Write Dept.C-10, for further information.

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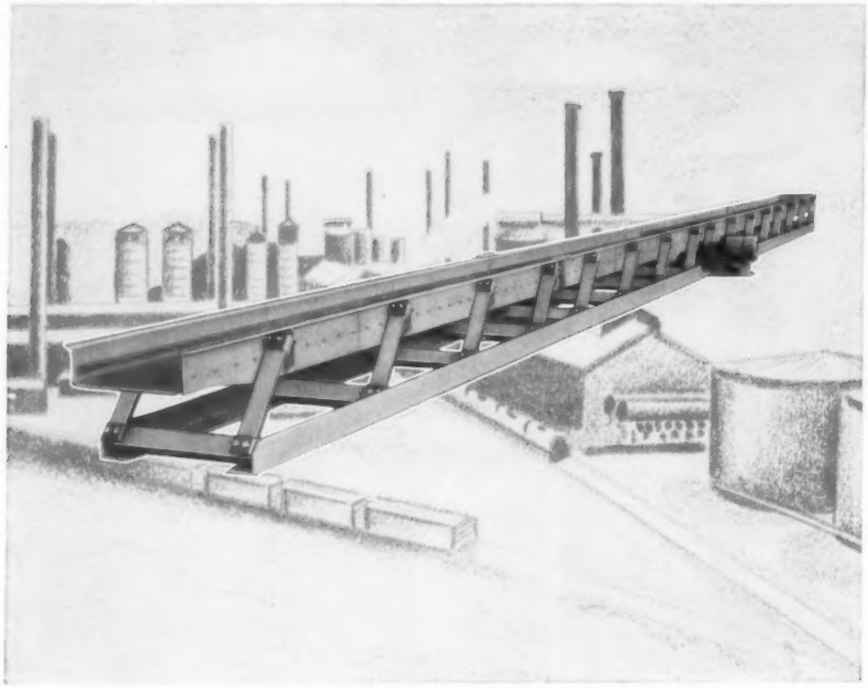
SYNTRON cost-cutting equipment of proven dependable Quality

conveys bulk materials at high rates



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VIBRATING CONVEYORS

—multi-purpose units designed for high speed conveying of bulk materials in densities ranging from 5 to 400 pounds per cubic foot and in sizes from powder to large chunks.

They can be fitted with screen sections to provide both conveying and screening.

Low initial cost—low power requirements—simple construction assures maximum performance with low maintenance.

SYNTRON Vibrating Conveyors are available in lengths and widths to meet most requirements.

Write for free informative Catalog today

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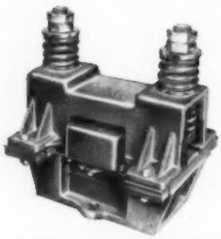
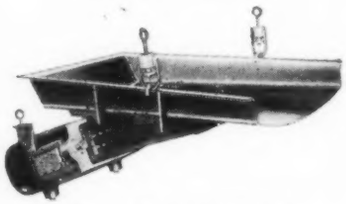
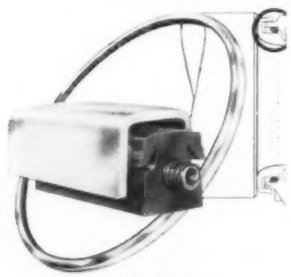


BIN VIBRATORS



VIBRATORY FEEDERS

VIBRATING SCREENS



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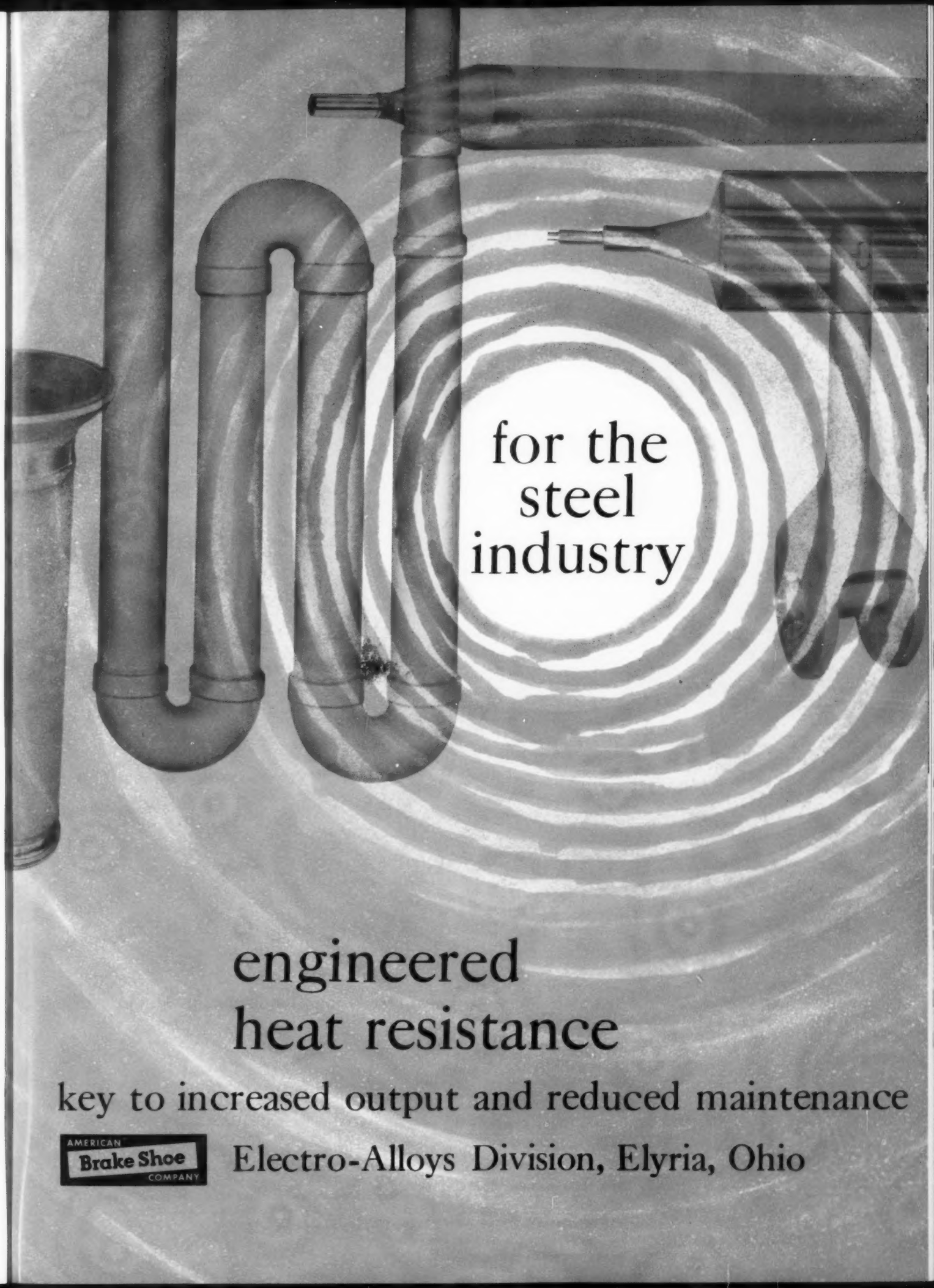
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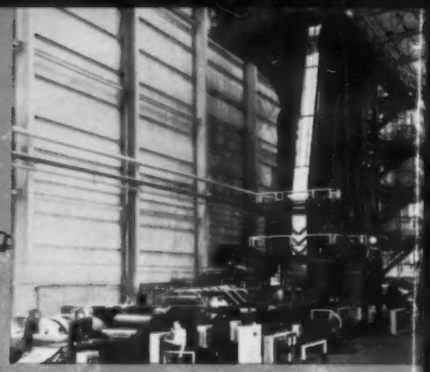
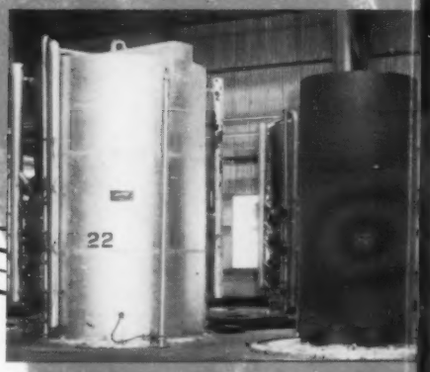
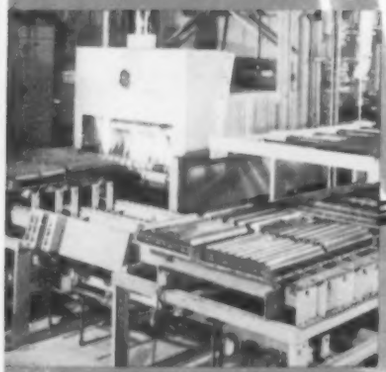


Continuous-Strip Annealing Furnace Rolls

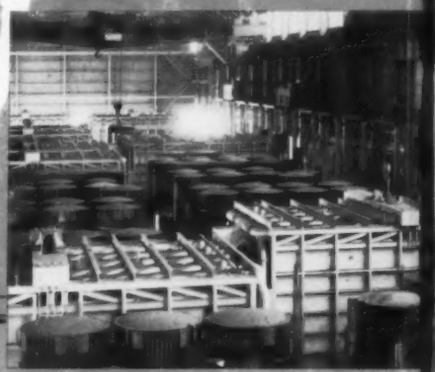
Sintering Machine Grate Bars



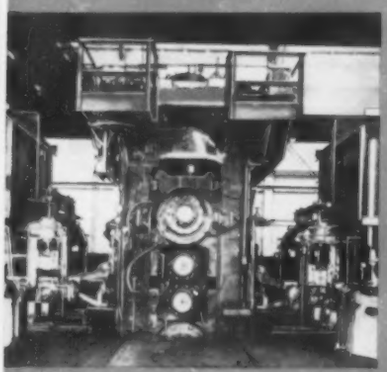
Single-Stack Annealing Furnace Radiant Tubes



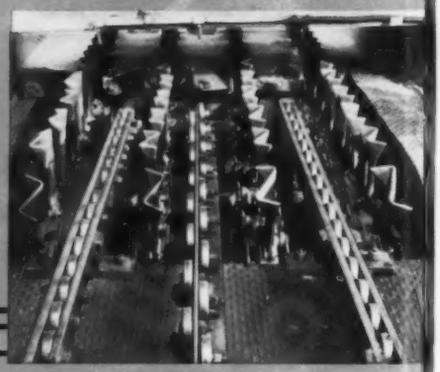
Roller Hearth Furnace Rolls



Multiple-Stack Annealing Furnace Radiant Tubes



One-Stand Four-High Reversing Mill Coiler Drums



Annealing Furnace Chain & Carrier Blades

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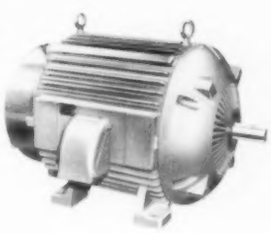
FOR EVERY APPLICATION, THERE'S ONE CRANE OUTSTANDING...

IN METAL FABRICATION . . . One man in the cab of this P&H overhead crane keeps several slitting and roll-forming machines supplied with coils of metal for continuous production. In addition, he spots incoming coils in proper storage areas as they arrive from the mills.

This manufacturer of standardized commercial buildings gets full use of plant floor area by moving materials through the air. The P&H crane and special coil-handling hook eliminates the "dead" aisle space needed with floor-operated equipment. It also saves manpower, and the safe, precision handling reduces damage to finished stock.

As with every Harnischfeger installation, this long-span (87′) crane is specially engineered to consider all factors that may affect operation on this particular job. Special problems are taken in stride, integrated into the overall design. Only this kind of integrated engineering can give you performance that's never in doubt, performance P&H crane users have relied on for over 76 years! Why not find out more about P&H "job-engineered" cranes? Write for bulletin C-42, Department 124, Harnischfeger Corporation, Milwaukee 46, Wisconsin.

All P&H motors are built specifically for crane service—not adapted to it! P&H engineers have designed extra ruggedness into every part for maximum efficiency under the most severe conditions of fast acceleration, frequent reversals, and repeated shock loads. Thousands of P&H crane motors in every-day use prove that they give years of trouble-free service with minimum maintenance.



P&H
OVERHEAD CRANES

HARNISCHFEGER
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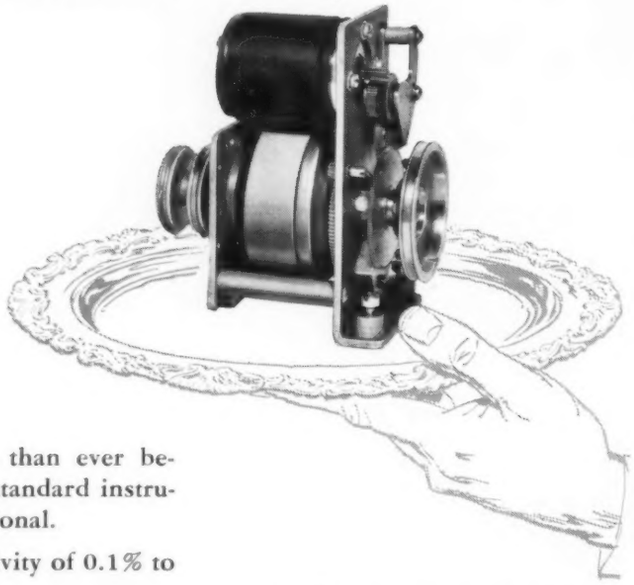
What makes **TRANSCOPE®** *Electronic and Pneumatic Recorders*

the most wanted miniature instruments on the market today?

The answer is Taylor SERVO POWER



In the past 2 years thousands of Servomatic motors have proven the inherent advantages of this Taylor innovation. Heart of the 90J (pneumatic) and 700J (electronic) recorders, it puts TRANSCOPE Recorders in a class by themselves. It is the most reliable device yet developed for converting an input signal into an accurate record. The tremendous power of these Servomatic motors—150 times greater than the bellows type (pneumatic), over 1,000 times greater than galvanometer systems (electronic)—gives you all these advantages:

- Greater accuracy than ever before—½ of 1% in standard instruments, ¼ of 1% optional.
- Threshold sensitivity of 0.1% to input signal.
- 3 months' ink supply mounted on the pen—no troublesome capillary.
- Lifetime recording accuracy—no critical pen pressure.
- No flimsy linkages and levers.
- Truly rectilinear chart—no curved time lines.

Plus these optional features: alarm contacts—retransmitting potentiometer—function generation—digital output with encoder discs.

* * *

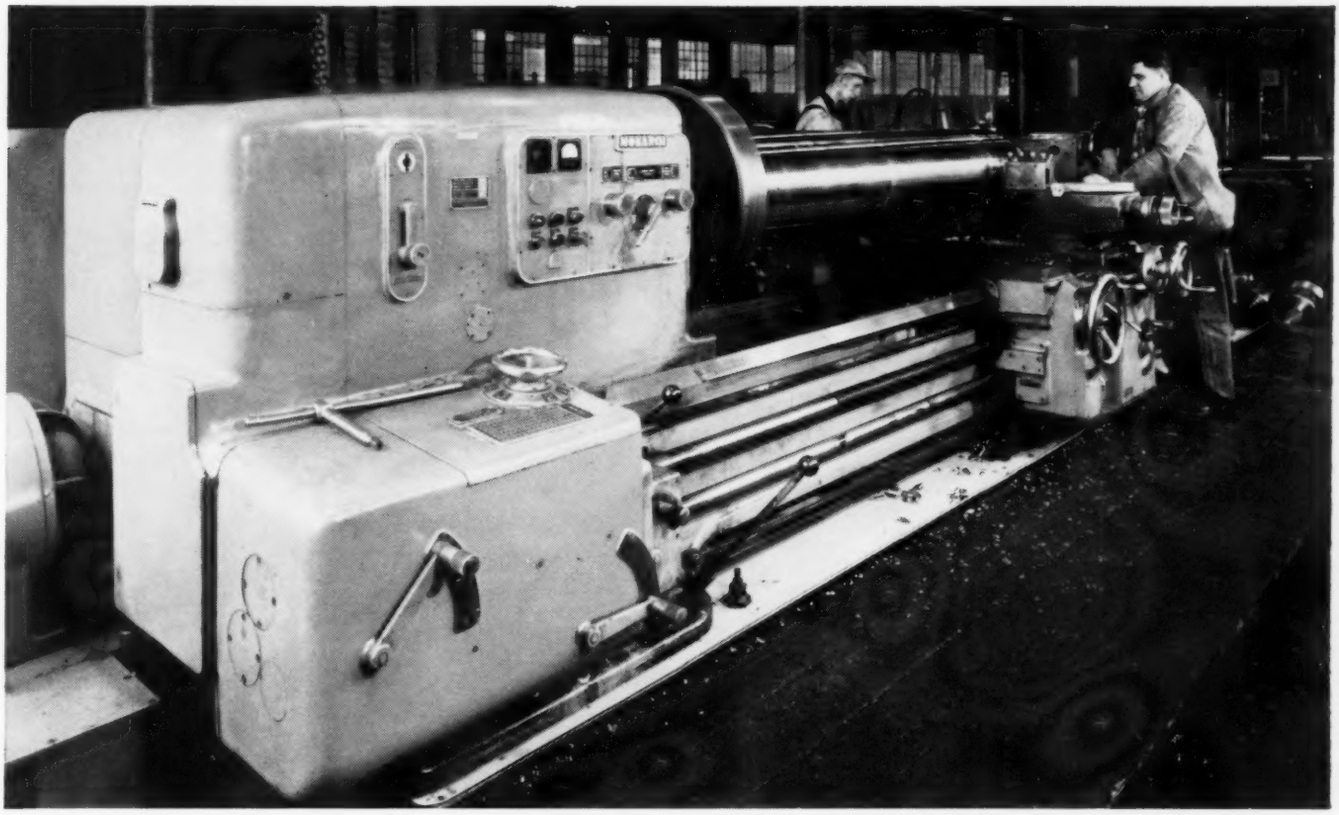
Ask your Taylor Field Engineer for full details of all the many superior features of TRANSCOPE servo-operated recorders. Or write for **Bulletin 98286** (pneumatic) or **98335** (electronic). Taylor Instrument Companies, Rochester, New York, or Toronto, Ontario.

Other TRANSCOPE advantages:

- Unconfused readability—because chart record, pen and set-point are side-by-side.
- 4″ chart reads from left to right—on rectilinear coordinates.
- Controller response adjustments may be made from the front—you can watch the results.
- Separate Plug-in Set Point Transmitters permit staying on automatic control—even when recorder slide is removed.
- All principal assemblies are plug-in mounted for flexibility and accessibility.
- Plug-in recorders and controllers permit housings to be shipped 4-6 weeks earlier than completed instruments to enable you to make all necessary connections to tagged manifolds.

Taylor Instruments **MEAN ACCURACY FIRST**

"Dyna-Shift" lathe ups output 25%, tool life 50%, —30 Timken® bearings maintain rigidity, accuracy



YOU merely set the controls of the Dyna-Shift drive on this Monarch Series 90 lathe to get the correct speed automatically. What's more, the "90" can be kept under full load at any speed, using modern tooling. Results, reports Monarch, show up to 25% more output and 50% greater tool life than with other equipment. Thirty Timken® tapered roller bearings at vital points—spindle, gear box, apron and tailstock—assure constant rigidity and accuracy, for maximum economy.

Most American machine tool builders use Timken bearings. Two big reasons are: 1) The taper lets Timken bearings take *both* radial and thrust loads or any combination. 2) Precision manufacture of Timken bearings assures high precision in the machine.

EXTRA ENGINEERING SERVICE. Often, our graduate engineer salesmen can solve your bearing problems on the spot, at the design stage, save you time and money.

THE FINEST GAGE LAB in the industry assures you top bearing accuracy. Some instruments we use measure even the thickness of a molecule, split a hair 30,000 times.

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The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO." *Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.* Canadian Division: Canadian Timken, St. Thomas, Ont.

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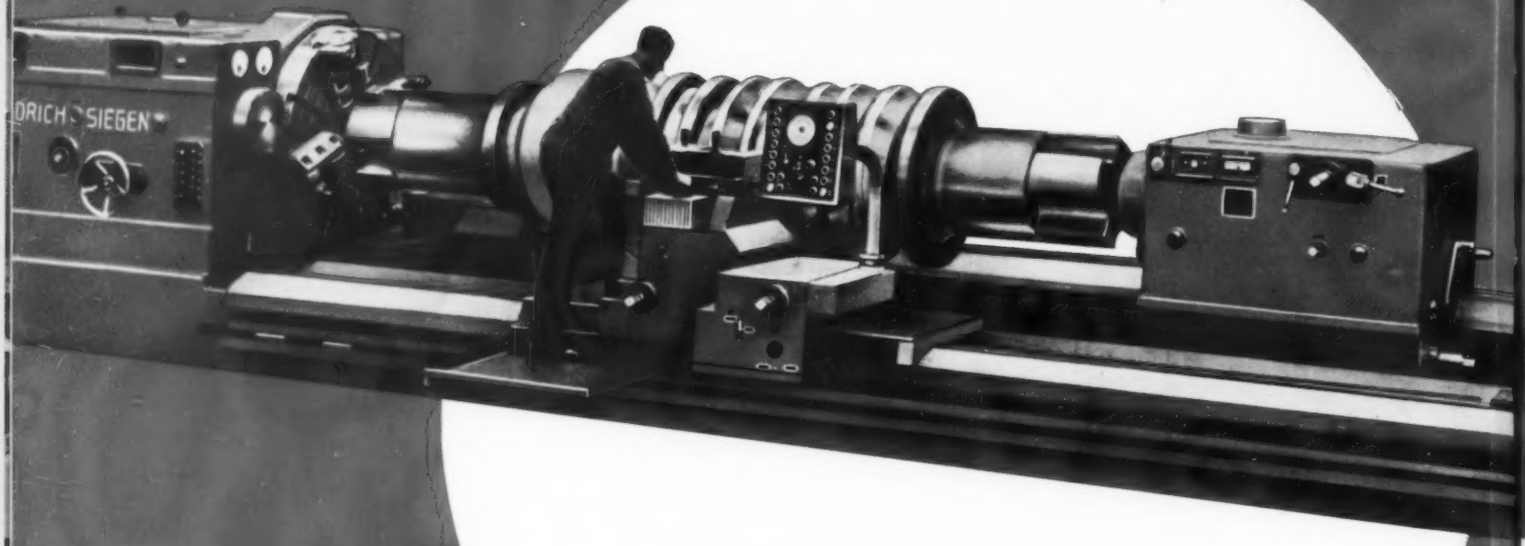

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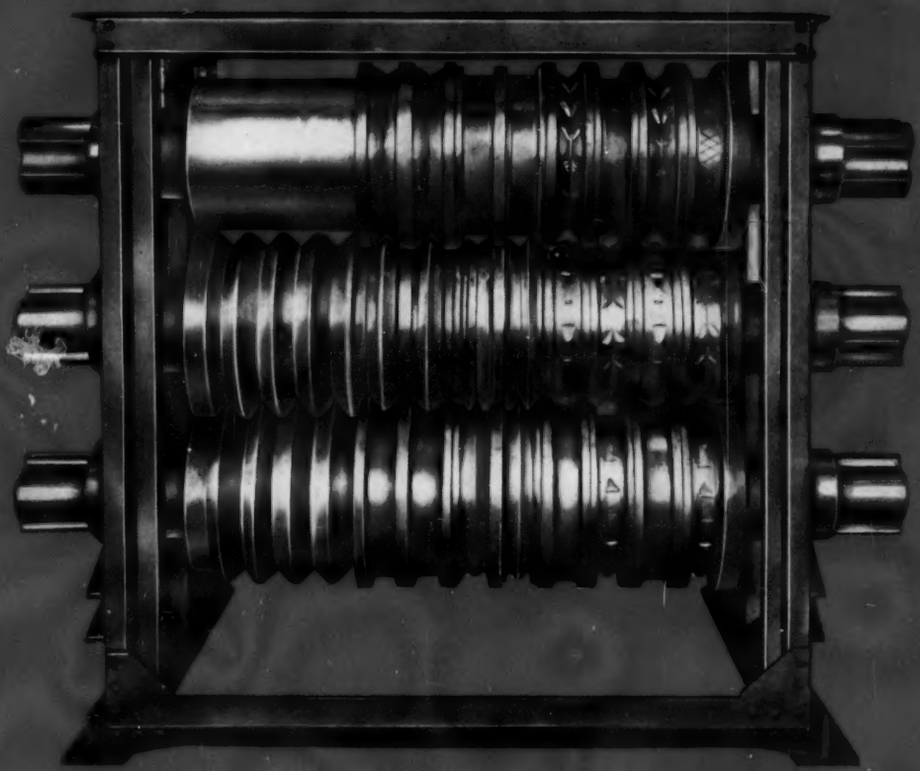
of turning operations from the punched tape to the finished roll



- **No need for specially trained operators**
- **No templates**
- **Longer service life of rolls, as our positioning system computes automatically the most favorable position of grooves.**

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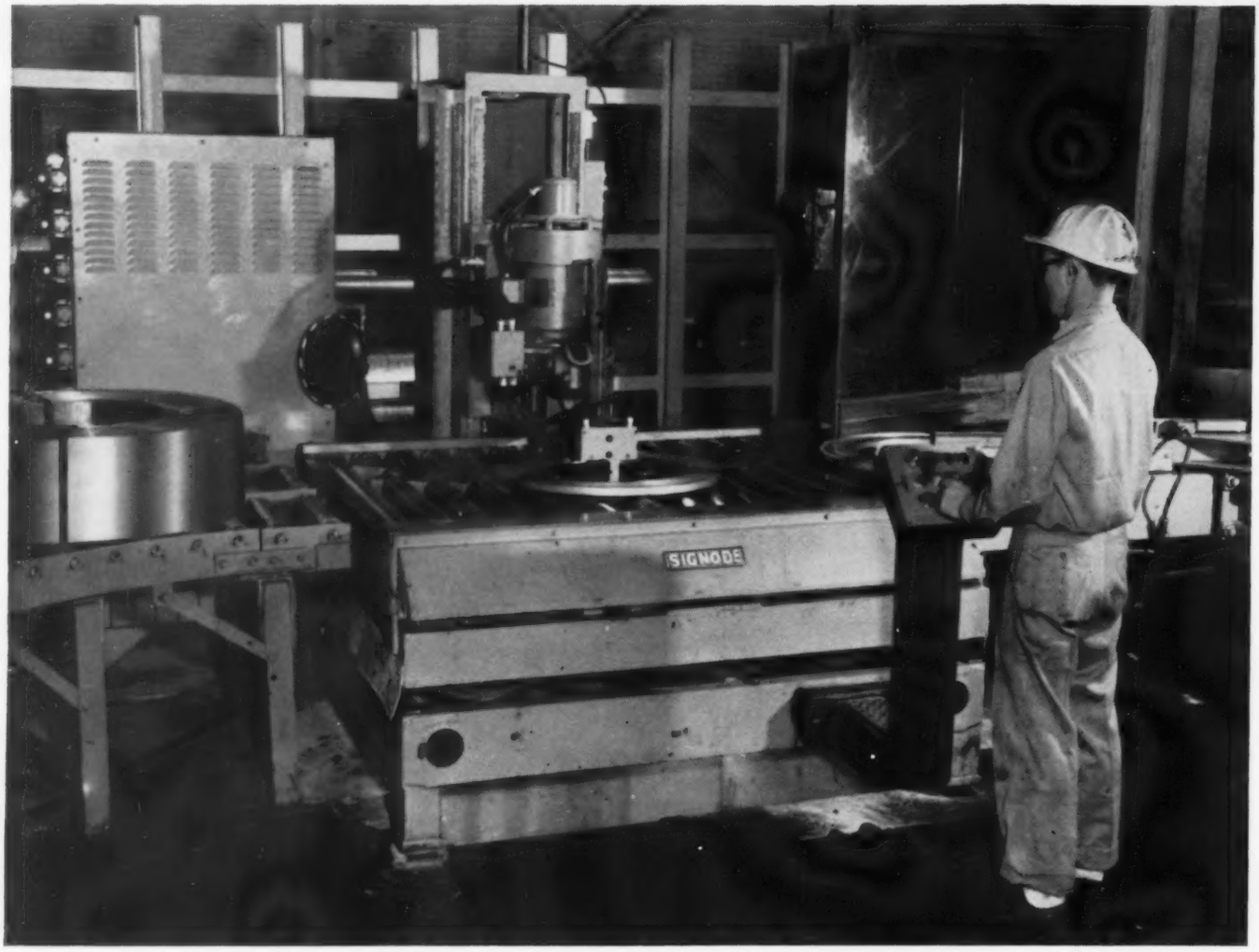

Fast new Signode M20 strip coil strapping machine

Push a button, and this Signode M20 feeds the strapping through the eye of the coil and tensions, seals, and severs it—all in a few seconds. Push another button, and the machine rotates the coil for the next strap. The operator can apply two, three, four or more straps per coil.

Mixed coil sizes are strapped at volume production speeds. The machine automatically adjusts for any coil height (width of strip) between ½ inch and 14 inches, and for any coil O.D. from 19 inches to 50 inches. Each strap is applied with the same pre-set tension. As on all M20's, tension is easy to adjust if desired.

The machine puts the seal on the upper face of the coil. There are several advantages to this: working parts last longer because they are subject to minimum dirt and grit, accessibility for servicing is excellent, the seal is in plain sight.

A wide range of M20's is available on a deposit or annual rental basis, for strapping products of almost any shape and size up to six feet in diameter, using strapping from ⅜ to ¾ inches wide.

Write for details, including free booklet, "Signode M20 Series Standard Power Strapping Machines."

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If it's necessary to whistle, shout or wave arms to communicate with crane and equipment operators in your plant, you're flirting with accidents, encouraging work lags, and inefficient operations. You can avoid them all with a system of direct, two-way voice communications.

Union Switch & Signal offers this system at a surprising low cost. The basic equipment includes transmitter-receiver units, loudspeakers, and microphones, and there is a full line of accessories to provide complete flexibility in design. Your own plant electricians can install the system—it uses existing electrical circuits. The system is easy to use—no special training needed. There's no transmission noise or outside interference—voice comes through loud and clear, and there's lots of audio power for your noisiest location.

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☐ Please send literature about Telecrane

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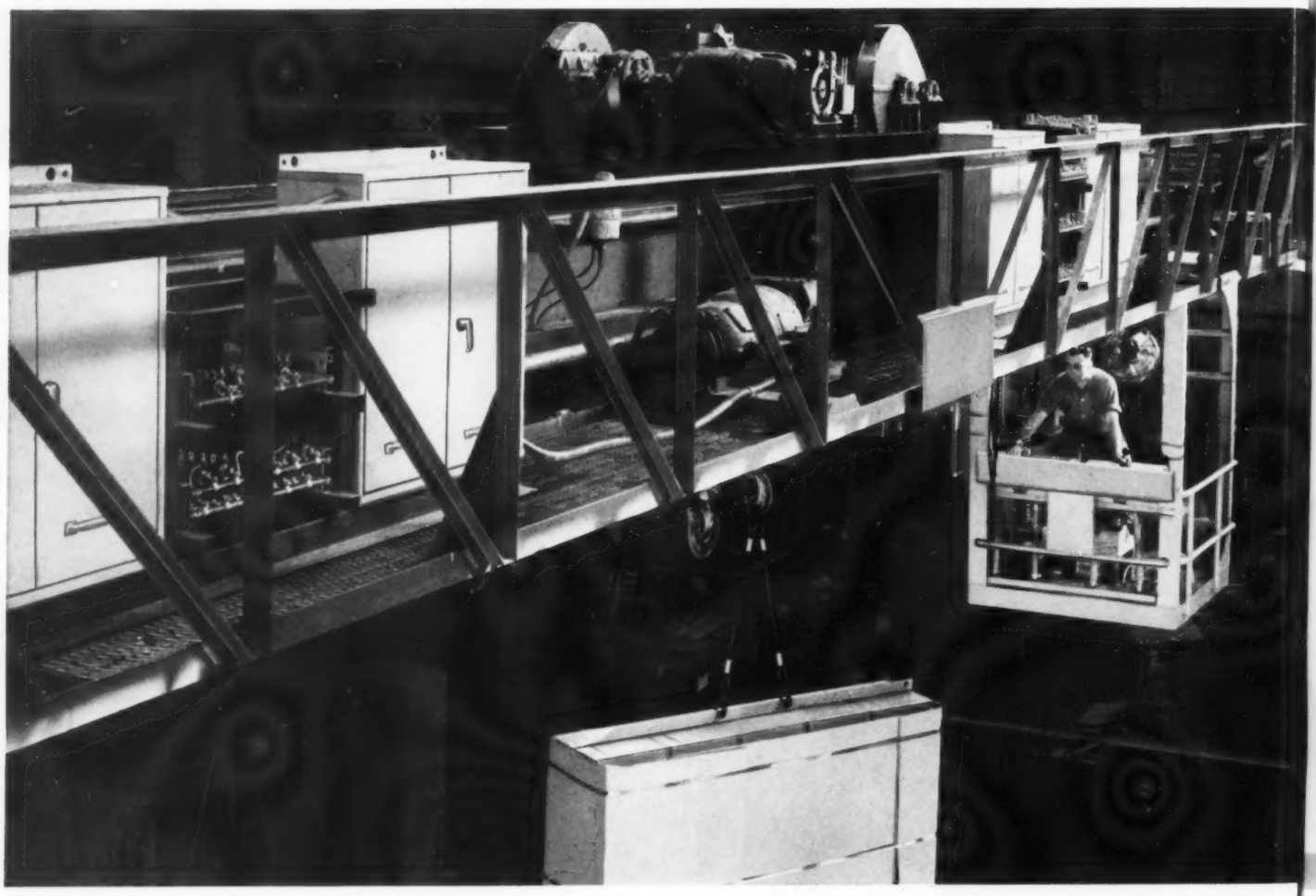
With General Electric's Complete "7400 Line"

GET STEPLESS



Now you can have ***completely*** stepless crane control —from full-speed lowering to full-speed hoisting— plus extremely accurate spotting. And this is just part of the story on General Electric's new "7400 Line." You also get substantially reduced maintenance: static devices are used in the control circuit to eliminate secondary contactors, relays and other moving-part components. Once energized, the IC7406 control can be operated through an entire hoisting and lowering cycle without a single control-panel component moving!

The "spotting zone" illustrated on the performance characteristic chart above is the operating area where accurate handling of valuable loads is most important. And this is where General Electric's IC7406 control really pays off! You can stop, momentarily hold, or reverse the load at "creeping" speed—without jogging!

General Electric's complete line of a-c crane controls also includes regulated and non-regulated control, both utilizing static components. Get the full story on the G-E "7400 Line" by contacting your G-E Apparatus Sales Office, or mail the coupon today!

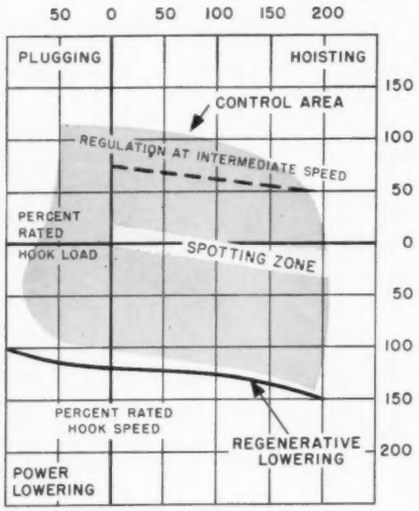
Progress Is Our Most Important Product

GENERAL ELECTRIC

of AC Reactor Crane Controls You Can . . .

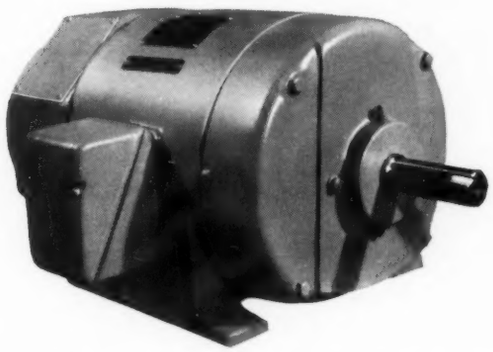
SPEED CONTROL

COMPARE THE PERFORMANCE AND FEATURES OF GENERAL ELECTRIC'S AC CRANE CONTROL



PERFORMANCE CHARACTERISTICS of General Electric's IC7406 static crane control.

COMPARE THESE FEATURES:	G-E IC7406	"A"	"B"	"C"
Reverses statically with no moving parts	✓		✓	
All magnetic components—no electronic tubes	✓		✓	✓
Balanced motor currents	✓	✓		
"Spotting zone" control for accurate positioning	✓			
Control from one master switch	✓	✓		✓
Completely stepless control	✓			
Total number of power contactors	1	2	3	8
Total number of relays (excluding overload relays)	2	4	6	13
Eliminates secondary accelerating contactors and relays	✓	✓		
Eliminates need for both electrical and mechanical load brakes	✓		✓	✓
Trolley collectors required	9	10	10	10
Flat speed-torque characteristic on *all* master switch positions	✓			



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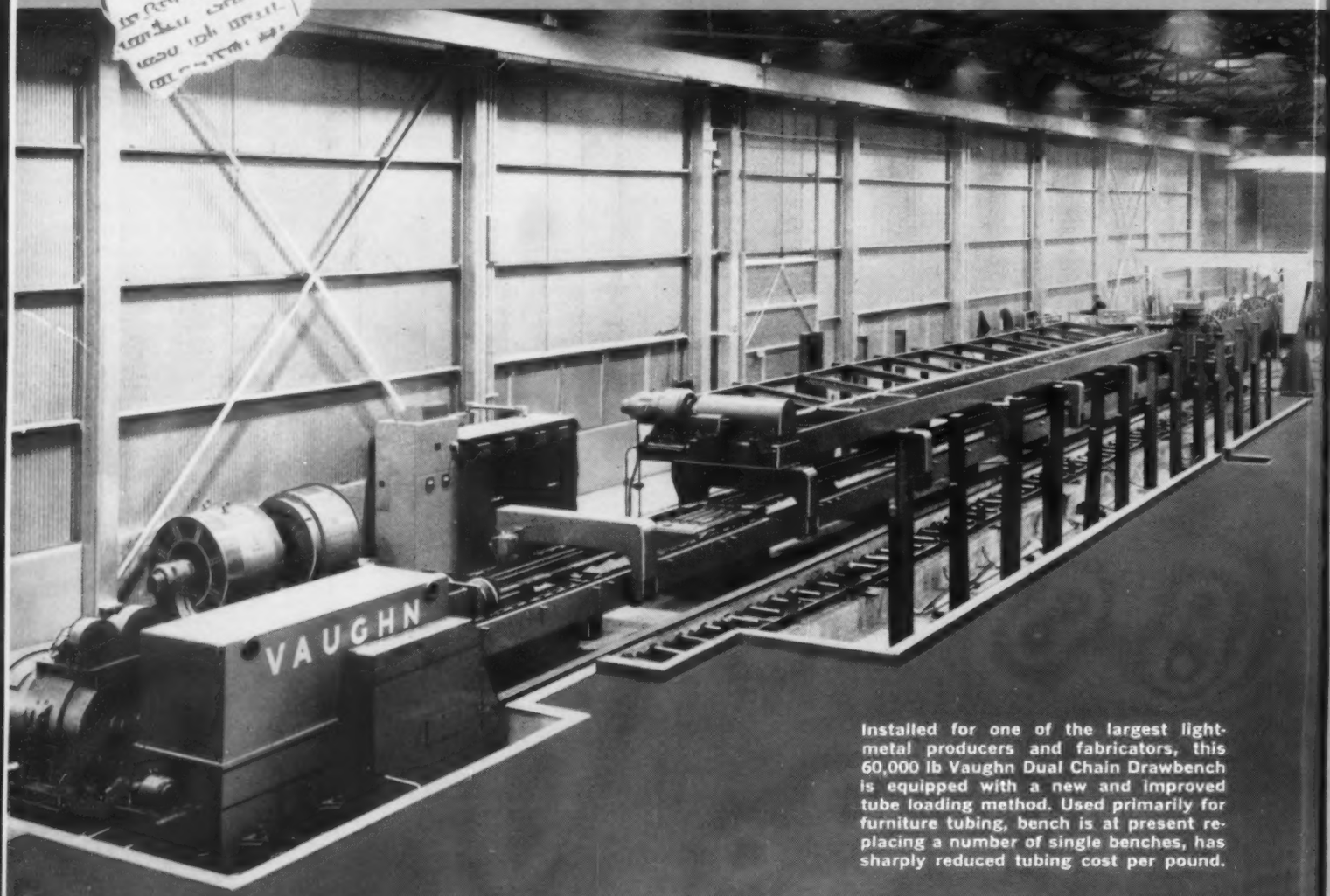
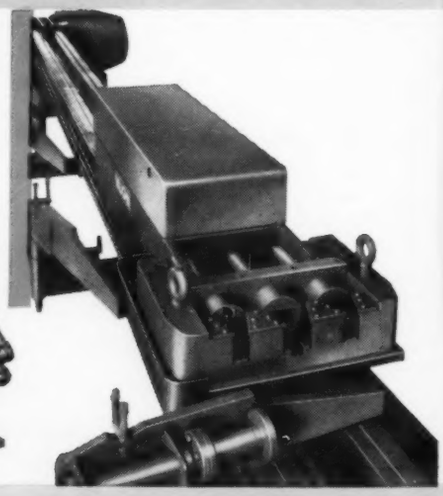


Installed for one of the largest light-metal producers and fabricators, this 60,000 lb Vaughn Dual Chain Drawbench is equipped with a new and improved tube loading method. Used primarily for furniture tubing, bench is at present replacing a number of single benches, has sharply reduced tubing cost per pound.

This Vaughn Bench pulls 60,000 pounds for an Illinois steel and wire producer. Bench points and draws three — 1¼" bar simultaneously.

Air-operated carriage and skid arm, equipped with push-off, on Bench shown at left. Carriage has shock absorbers for each bar operating independently.



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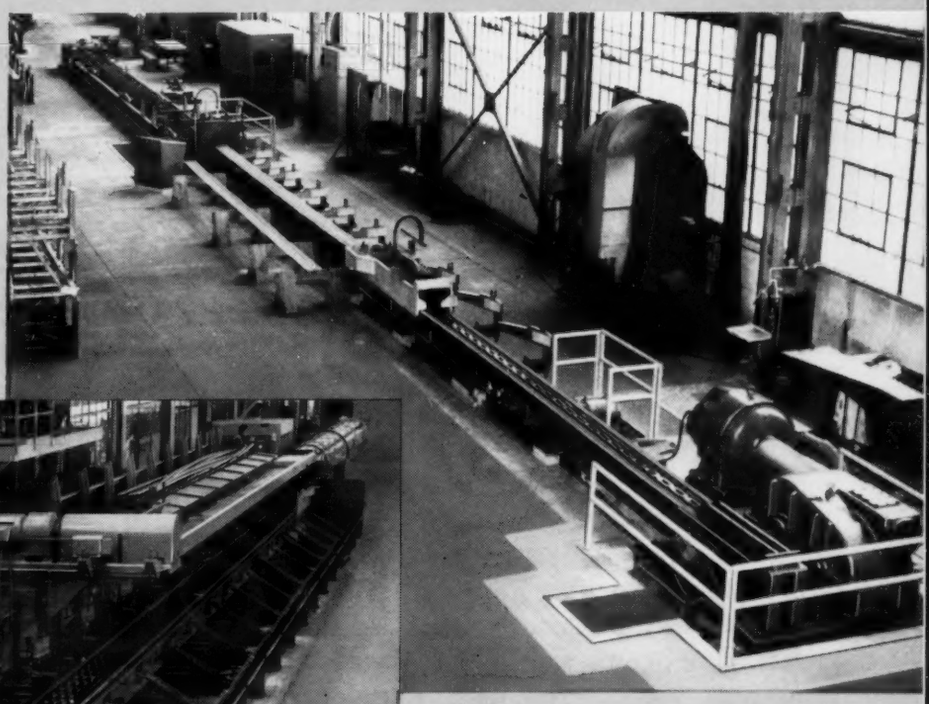

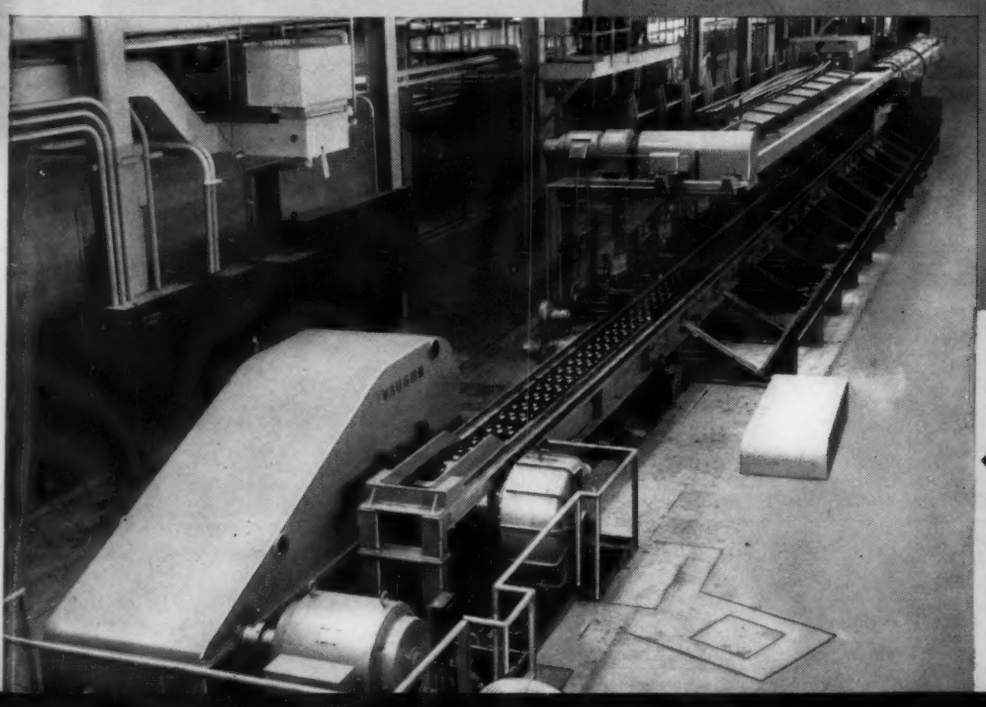

For another Illinois producer, this Vaughn Drawbench is equipped for bars, tubes and shapes. It is used primarily for shaving magnesium on a production basis.

Installed at a large Canadian tubing producer, this Vaughn Drawbench includes roll-over mandrel end, carriage tube shock unit and air clutch. Canada's largest-ever order for copper tubing was recently drawn by this bench.

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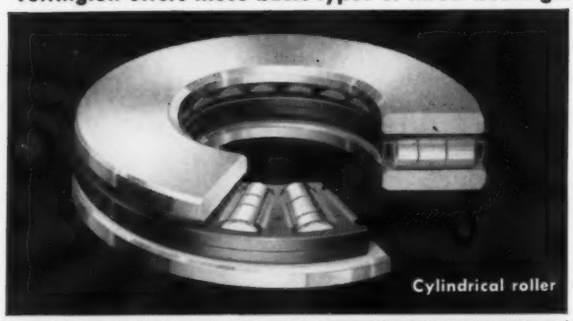

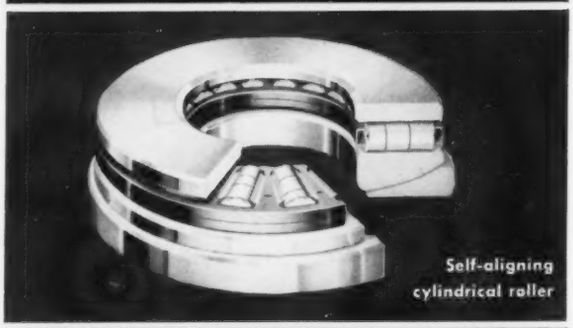

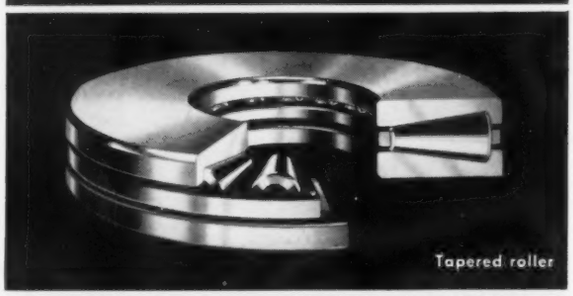

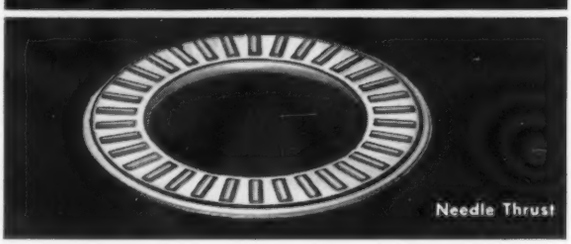

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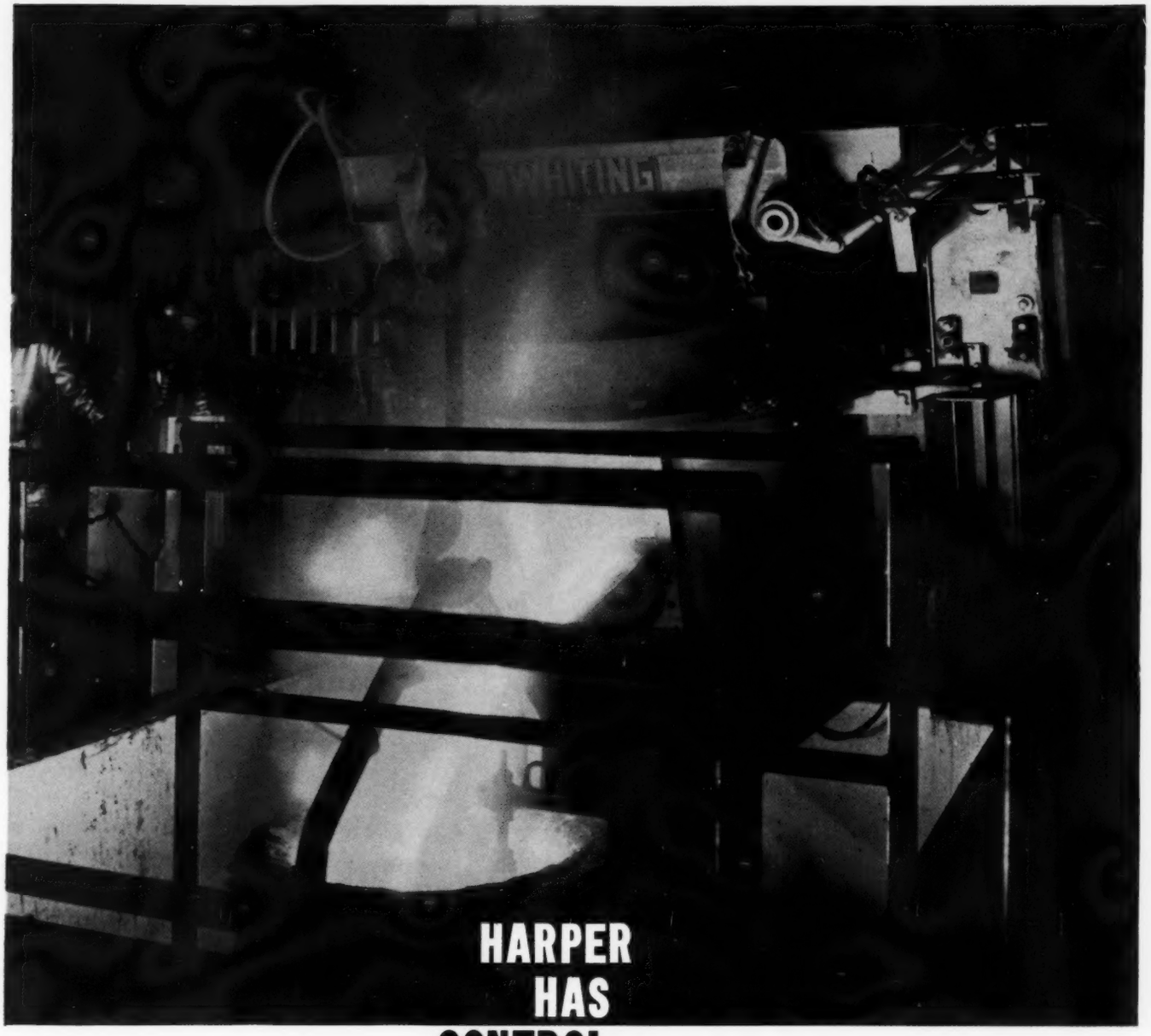

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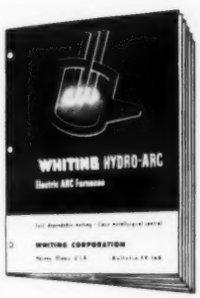

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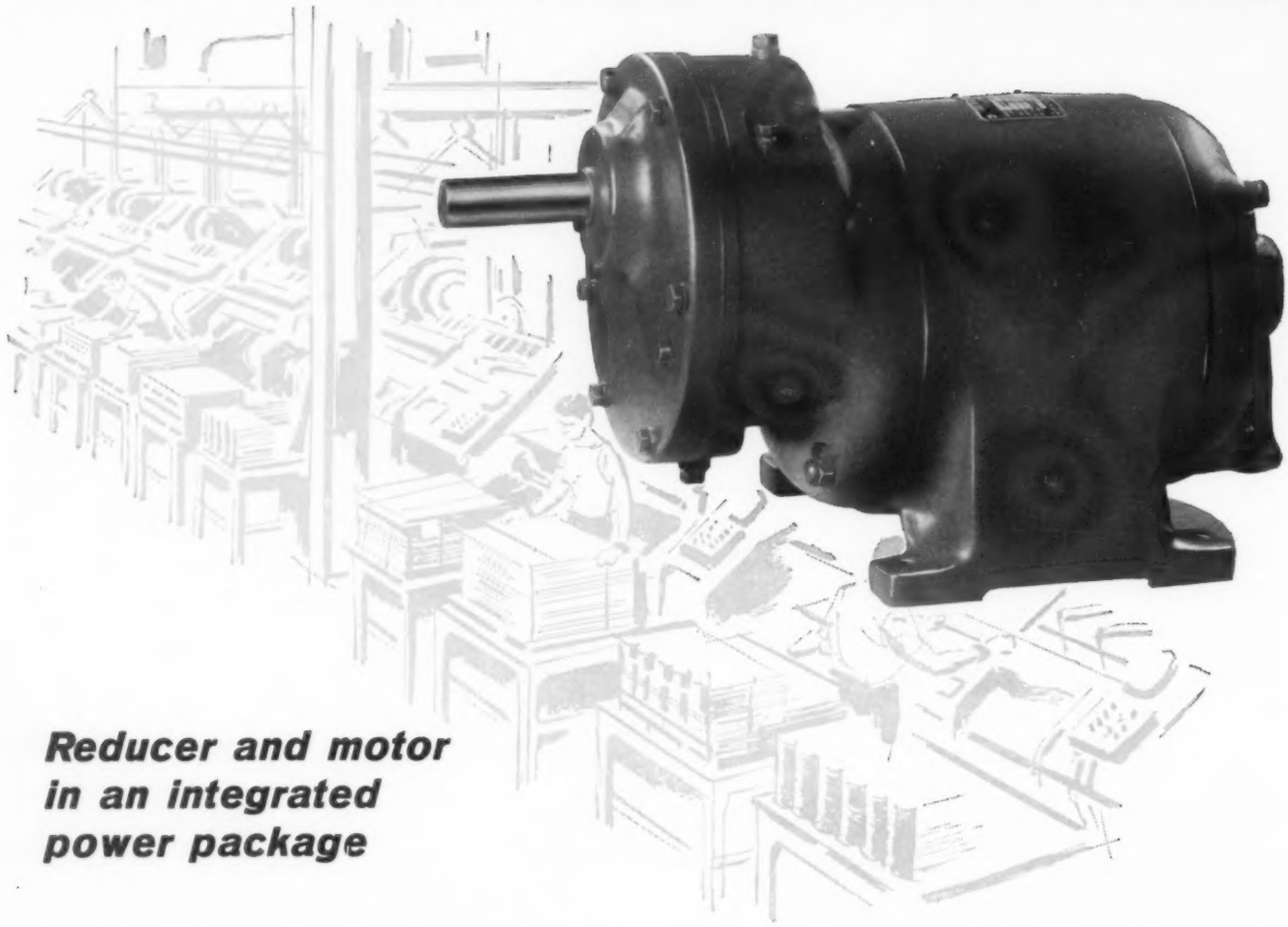

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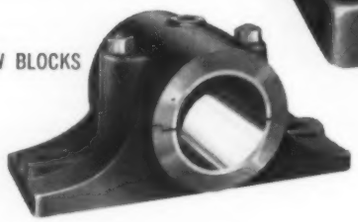

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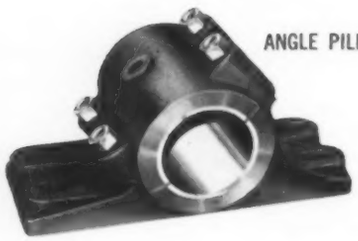

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Symposium On Basic Oxygen Furnaces

The following papers were given in a panel sponsored by the Steel Works Section of the Engineers' Society of Western Pennsylvania at its March 15, 1960 meeting in Pittsburgh, Pa.

EQUIPMENT LAYOUT

by STEPHEN VAJDA
Staff Process Design Engineer
Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.

As of January, 1958, there were 26 basic oxygen furnaces in the world with an annual ingot capacity of 7,000,000 tons of which eight were in North America with a capacity of 5,000,000 tons. The largest of these was rated at 65 tons.

As of January, 1960, two years later, there are 90 furnaces built or being built with an annual capacity of 28,000,000 tons. Of these, 23 are in North America with a capacity of 12,000,000 tons.

Aside from three 110-ton vessels proposed in England, the average vessel used throughout the world is rated at about 45 tons. On the other hand, in North America the average vessel size is about 100 tons with the largest one being talked about being 250 tons.

From the above, it is evident that there is a "furnace explosion" going on. Furthermore, although the United States did not give birth to the process, it has certainly taken hold of it and nourished it far beyond the fondest dreams of its parents.

It is, therefore, appropriate to take a brief look at the step-by-step progress in this rapidly evolving process and see the general trend in the various segments of layout and equipment.

The various plants compared will be discussed in the order of their coming into existence. See following tabulation:

FURNACE CAPACITY

Plant	*Startup*	*Rated size No.*	*Rated size Tons*	*Production tons*	*O_2 blown, cfm*
Dofasco	Oct., 1954	2	30	50	3000
	Dec., 1956	1	60		
McLouth	Dec., 1954	3	35	50	3500
	April, 1958	2	80		
	March, 1960	1	110		
J&L Aliq.	Nov., 1957	2	65	81–108	6000–8000
Algoma	Nov., 1958	2	65	100	8000
Fontana	Dec., 1958	3	65	120	
Acme	Jan., 1959	2	55		3000–4000
C F & I	1st qtr, 1961	2	100		
J&L Cleve.	2nd qtr, 1961	2	200		12,000–20,000
Gary		2	185		
Great Lakes		2	250		

Thus, vessel capacity has gone from 50 to 250 tons and in O_2 blown from 3000 to 20,000 cfm.

GENERAL LAYOUT

Dofasco	3 aisles—slag, furnace, teeming. Hot metal and scrap charging, teeming, stripping, stopper rod preparation in teeming aisle under one runway.
McLouth	2 aisles—furnace and teeming. Original three furnaces in 27-ft pits.
J&L Aliq.	4 aisles—scrap, charging, furnace, teeming. Scrap aisle integral with shop.
Algoma	3 aisles—slag, furnace, teeming. Hot metal and scrap charging in teeming aisle.
Fontana	3 aisles—charging, furnace, teeming.
Acme	5 aisles—scrap, bin, converter—cupola, hot metal, teeming.
CF&I and, J&L Cleve.	3 aisles—charging, furnace, teeming. Scrap yard parallel but not integral with shop. Two layouts almost identical.

General layout has crystallized into a shop with three aisles—charging, furnace and teeming. Depending on the plant layout and other furnace installations, the scrap yard can be anywhere—preferably adjacent to the basic oxygen furnace but not necessarily integral with it.

SLAG HANDLING

Dofasco	Slag pot carried from furnace aisle by transfer car into slag aisle, permitted to solidify in pots, hauled away in pots by truck.
McLouth	Slag pot carried from furnace aisle by transfer car into teeming aisle, lifted by crane on to railroad buggy.
J&L Aliq.	Diesel pulls buggy with two slag pots from under furnace into scrap yard, make up a train and haul away.
Algoma	Single 180-cu ft slag pot carried from furnace aisle by transfer car into slag aisle. picked off by crane and allowed to cool 16 hr, dumped into bottom dump truck and hauled away.
Fontana	Single 312-cu ft rectangular pot carried from furnace aisle by transfer car into teeming aisle, crane places pan on railroad car.
Acme	Single slag thimble carried from furnace aisle into hot metal aisle on same transfer car as steel. Crane places pot on railroad car.
Cleve.	Two 500-cu ft slag pots carried from furnace aisle by transfer car into charging aisle, crane places pots on railroad car.

Two other methods given thoughtful consideration are:

1. Dump the slag on the ground and load into a truck with a front end loader.
2. Pick up and carry the slag pot with a solid-tired mobile.

In general, the accepted way is to use slag pots on a transfer car and unload in the charging aisle by crane on to railroad cars.

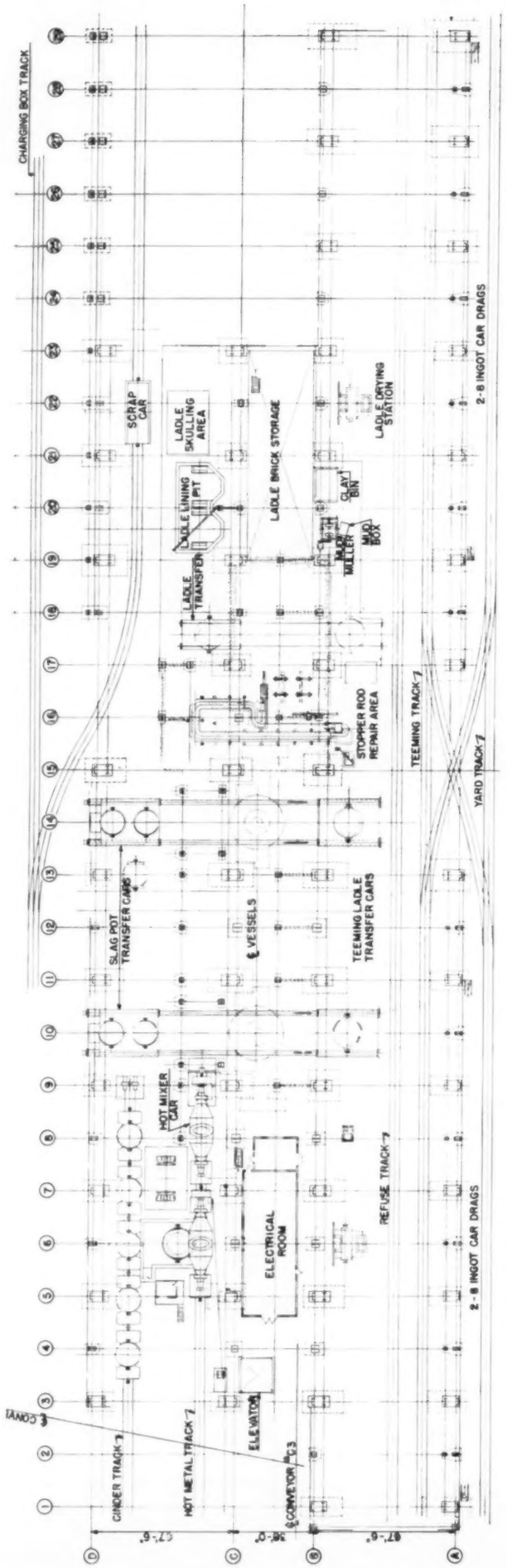

Figure 1 — Plan at yard level of new basic oxygen furnace plant at Cleveland works of Jones & Laughlin Steel Corp.

IRON HANDLING

Dofasco	Arrives outside teeming aisle in submarine ladle. Reladled into pit in teeming aisle by runners. Scale in pit.
McLouth	Arrives in furnace aisle in submarine ladle. Reladled into 40-ton ladles which are placed on transfer car by crane. Charged from car into furnace in pit.
J&L Aliq.	Arrives in charging aisle in submarine ladle. Reladled into pit with scale. Crane carries ladle to furnace. Car puller for spotting submarine ladle.
Algoma	Arrives in slag aisle in submarine ladle. Scale under submarine ladle. Reladled into ladle on transfer car in pit. Taken to combined charging and teeming aisle.
Fontana	Arrives in charging aisle in submarine ladle. Reladles into pit with scale. Crane carries ladle to furnace. Locomotive for spotting submarine ladle.
Acme	Only plant which uses hot metal from cupola instead of from a blast furnace. Continuous tap into mixers. Reladled into pit with scale. Crane carries ladle to furnace.
J&L Cleve.	Arrives in charging aisle in submarine ladle. Reladled into pit with scale. Crane carries ladle to furnace.

Although the iron is arriving in every aisle—and even outside an aisle as at Dofasco—the preferred way seems to be to reladle it in the furnace aisle and then charge it into the furnace by crane.

SCRAP HANDLING

Dofasco	Received in railroad cars, loaded into five 18-ft long boxes on a transfer car, taken into teeming aisle over a scale, charged individually by crane.
McLouth	Electric driven, side-dump charge car with four boxes. The three new furnaces are charged by bottom dump buckets similar to electric furnace.
J&L Aliq.	Charging platform extends into scrap yard. Scrap crane unloads railroad cars into four self-tilting boxes mounted on a car pulled by an electric mule. Car rests on scales. Scrap tracks permit spotting one day supply—only emergency pile on ground.
Algoma	Use open hearth scrap yard. Twelve to 15 tons per box. Carried to furnace by straddle truck carrier (50,000-lb capacity.) Deposit boxes under crane in teeming aisle. Handle three to four boxes per hr.
Fontana	Received in railroad cars, loaded into 20-ton charging chutes on transfer car on a 50-ton scale. Scrap cranes lift individual chute.
Acme	Charging platform extends into scrap yard. Scrap crane unloads railroad cars into two long, open ended boxes on transfer car. Double hoist dumps each box into furnace.

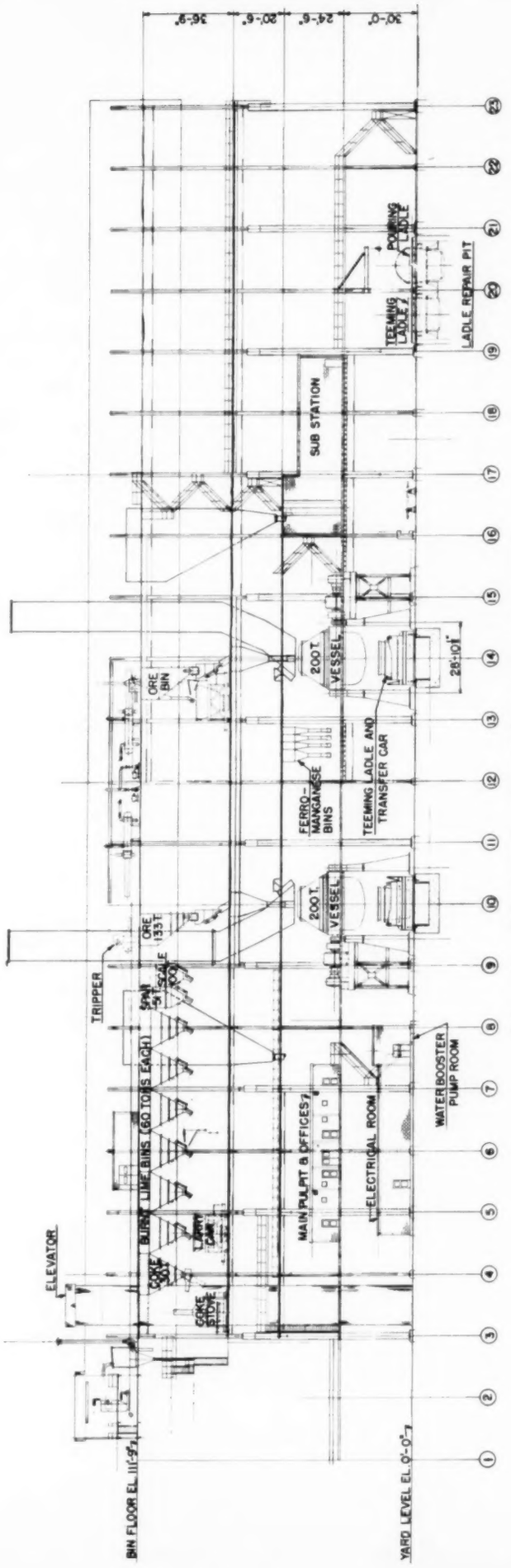

Figure 2 — Plant will have two 200-ton converter vessels.

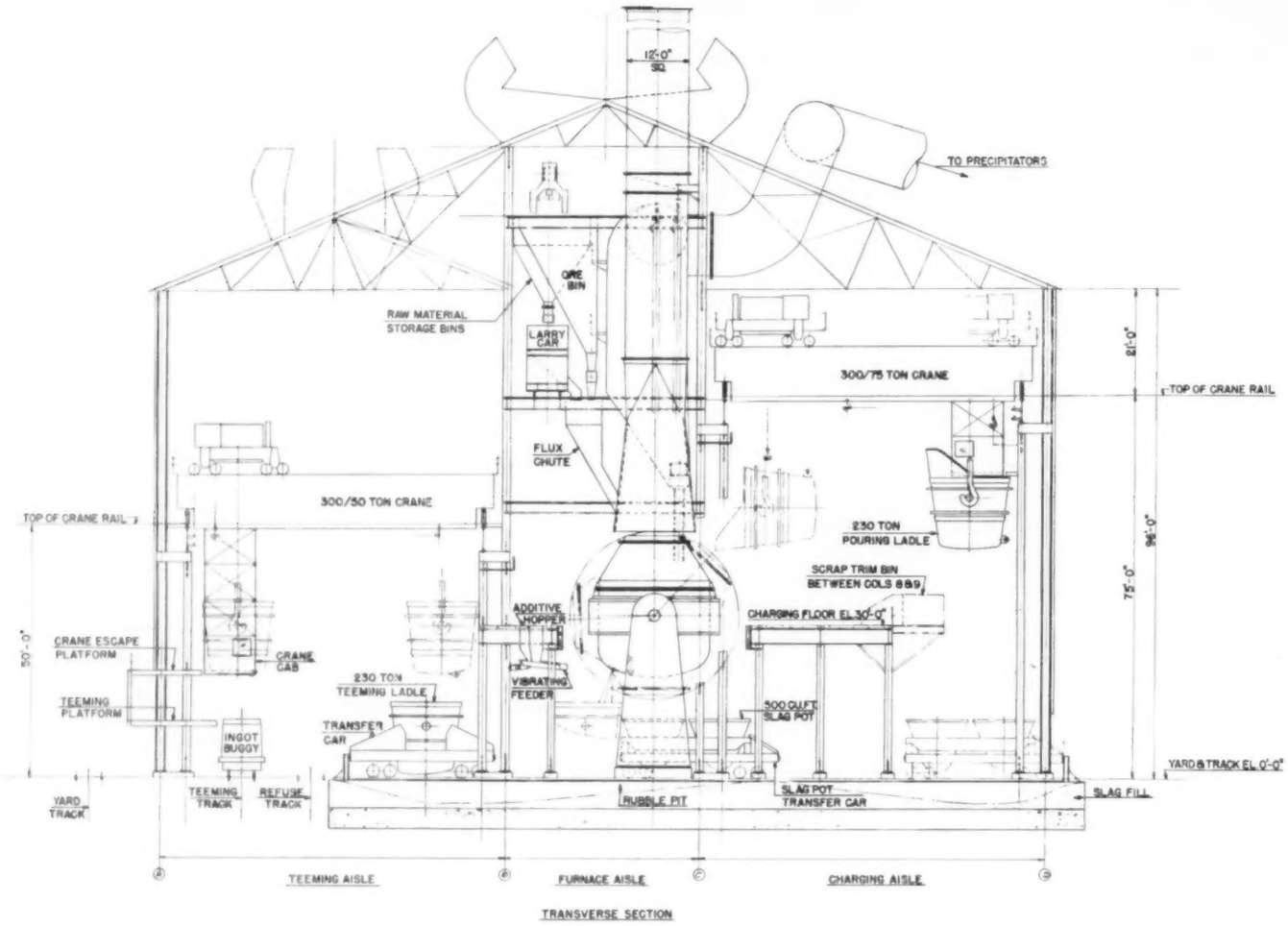

Figure 3 — Transverse section through plant.

J&L Cleve. Received in railroad cars, loaded into 70-ton charging car, switch car to charging aisle, crane places car on scale on charging floor. Trim. Spot car in front of vessel. One shot scrap charging.

The two quickest and most efficient means of scrap charging are the self-dumping box car and the special charging car. Each has its advantages and disadvantages. The special charging car is the quicker, but possible heavy maintenance and higher building costs may offset this. If scrap is received in railroad cars, it should not be laid on the ground.

ADDITIVES

Dofasco Track hopper, elevator, overhead bins in furnace aisle. Weigh larry discharges into four separate hoppers and a "man-cab" operating on a monorail system. Water-cooled chute extends through hood.

McLouth In the original shop overhead bins using a pressure system. Handled automatically through scale-hung primary collectors into hoppers which empty into swinging chute.
New shop has bins on the ground and uses a vacuum system to inject it into the furnace.

J&L Aliq. Track hopper, conveyor, skip hoist, overhead bins in charging aisle. Self-propelled weigh larry car discharges into furnace by chute. Addition during blow made by separate weigh hoppers.

Algoma Track hopper, skip hoist via conveyor to overhead bins in furnace aisle. From bins to furnace by 6-hopper mule train.

Fontana Track hopper, conveyor, overhead bin in furnace aisle. Twelve day bins with weigh hoppers. Hold bin at furnace. Limestone and lime direct to hold bin. Automatic weighing system.

Acme Track hopper, conveyor, overhead bin in bin aisle. Monorail carrier with five hoppers transports material into furnace aisle.

J&L Cleve. Track hopper, conveyor, overhead bin in furnace aisle. Larry car with weigh cells into chute into furnace. One bin with weigher direct into furnace.

One could certainly reduce building costs if one could keep the storage bins on the ground. The pneumatic systems to-date have proven controversial. With the overhead bins one has up to 12-hr storage to tide one

over minor troubles. Skip hoists are being replaced with conveyors, if possible.

TEEMING

Dofasco	Transfer car teeming at one end of aisle. Ingots bottom-poured on three tracks with pouring platform between. After stripping, hauled to soaking pits in insulated trucks.
McLouth	Transfer car, single teeming platform.
J&L Aliq.	Transfer car, single teeming platform.
Algoma	Transfer car, single platform, 125 ft long. No hold time (15 per cent rimmed steel) Moved immediately outside for proper hold time.
Fontana	Transfer car, single platform. Stripping in same aisle.
Acme	Transfer car, two parallel pouring platforms. Molds rest on the ground in three parallel rows. Ingots stripped in teeming aisle.
J&L Cleve.	Transfer car, two platforms 300 ft long each.

With such a process as this producing heats with clock-like regularity, the teeming platform soon becomes a bottle-neck. The United States have not seen fit to emulate the European practice of parallel pouring aisles, but as the shop capacity goes up, there may be no choice.

HOODS

Dofasco	Round, water-cooled, 124-ft vertical stack. Fixed.
McLouth	Round, water-cooled, retractable on rails. New furnace uses post job crane to move hood.
J&L Aliq.	Rectangular with combustion chamber. Water-cooled panels. Mounted on wall crane to move for rebuild.
Algoma	Water-cooled.
Fontana	Circular, water-cooled. Fixed. 64 sections. Two sections swing open for brick lining.
Acme	Circular, water-cooled. Fixed. Vertical stack.
J&L Cleve.	Round, water-cooled, vertical stack. Fixed.

Design of the hood has varied with the type of gas cleaning, the proposed method of relining the furnace, and the attempts to reduce infiltration. Aliquippa put in a combustion chamber to make sure no CO would reach the precipitator. McLouth put the hood down on the furnace to reduce infiltration. European practice incorporates a vertical stack for emergency use in case of fan failure. No one has seen fit to adopt another European feature—that of incorporating a waste heat boiler into the stack.

CLEANING SYSTEMS

Dofasco	Spark box, three venturi scrubbers, three cyclone separators (use only two). Fans rated at 450-hp, 70,000-cfm each.

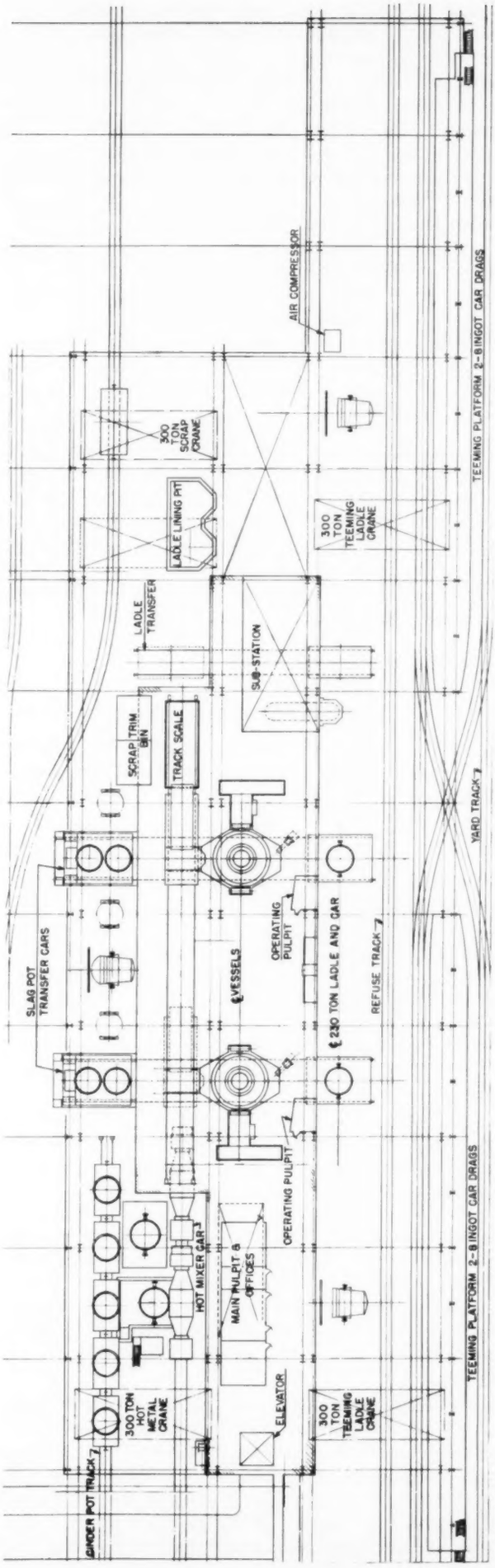

Figure 4 — Plan shows yard level and charging floor.

McLouth	Spark box, wet washer, disintegrator, 100,000 cfm. New furnace uses similar system.
J&L Aliq.	Spark box, precipitator. 139,000-cfm fan, 500-hp.
Algoma	Spark box, one primary, three secondary scrubbers in parallel. 60,000-cfm fans. Original 600 hp—being charged to 800 hp.
Fontana	Spark box, three precipitators, 200,000-cfm each.
Acme	Brick-lined duct to cooling tower (23 ft x 26 ft-6 in. x 40 ft) dry type precipitator. 200,000-cfm, 6 in. H_2O, 250 F.
J&L Cleve.	Spark box, several precipitators (combined open hearth and oxygen furnace). 400,000 cfm for oxygen converter.

The gas cleaning systems are divided between the high-drop scrubbers and the precipitators. The wet system has the disadvantage of high horsepower (Algoma found 45 in. was not enough) and water clarification. The precipitator has a potential explosion hazard and a dust disposal problem. Another controversial point is the duplication of the cleaning system for each furnace vs one single fan and cleaner.

VESSEL AND LANCE DESIGN

by J. REICHMAYR
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IT took 27 years after the introduction of the open hearth process in the United States, for the infant industry to attain an annual ingot production of one million tons in 1895. In 1959, just five years after the first basic oxygen furnace was blown in at McLouth Steel, a million tons of ingots were produced by this new method. This production is exceptionally remarkable when one realizes that the first commercial operation of this process was in 1952 in plants in Linz and Donawitz, Austria.

To understand this steel production revolution, it is necessary to understand the development of the furnace design, and the rapid increase in furnace capacities.

The early L-D converters were essentially bessemer furnaces, with 30 to 38-ton capacities. They were designed with a slender silhouette, blew approximately 3500 cfm oxygen, and the average lance distance was only three or four feet. Note that one design (Figure 1a) retained the bessemer removable bottom. The two ladles in Figure 1b are typical of current thinking for large units.

There was only one exception to the bessemer type design, a 25-ton German furnace built with a spherical shape. In the United States, another semi-spherical furnace was derived by taking the actual wear line of existing furnaces, when blowing oxygen at rates of 4000 scfm and refining about two tons of steel per minute. It was found that most wear occurred a few feet above the slag line, with the least abrasion at the knuckle radii of the furnace bottoms. Since the first spherical furnaces were put into operation, a definite trend toward the larger diameter, rounder silhouette has been apparent. At the same time, there has been a strong tendency to build basic oxygen vessels of the same capacity per heat as the present large open hearth furnaces.

Many studies have been made in an effort to determine the best furnace shape for specific heat sizes, and refining rates. Domestic research centers have operated experimental furnaces with capacities up to eight tons for metallurgical or oxygen flow data.

The aerodynamic principles of the top-blowing jet have a most significant effect on furnace shape. Figure 2 shows characteristics of the supersonic turbulent oxygen stream blowing from certain distances above the metal bath. Flow speed, stream volume, impact diameter, and impact pressure vary with lance distance above the bath. These data have been determined by actual test.

The kinetic energy of the primary, as well as of the deflected secondary, oxygen streams has been evaluated. Due to the opening of the oxygen jet, penetration power of the stream decreases with growth of impact diameter, while volumetric bath displacement and the surface tension on the bath diameter increases with the third and second power respectively of the impingement force. Plastic models filled with mercury have been submerged in water, then colored blowing streams introduced at various pressures and lance distances to study the effect of streams using different vessel shapes.

Supplementing studies of blowing mechanics, metallurgical research is under way to study oxygen consumption on the bath surface, which evidently increases with the bath impact area. In this regard, the metal bath depth is of interest in that static height prevents any bottom damage. The absolute furnace height, particularly height above the bath or internal volume/ton yield is related to the absorption of kinetic energy of the secondary deflected oxygen jet, the discharge of CO and CO_2 gases and the prevention of slopping. To illustrate, it has been found that even the slag deposit pattern along the descending lance will vary with the blowing condition.

Since the lance tip wears off when exposed to heat and slag, considerable research has been aimed at protecting the tip in order to obtain and retain the best discharge condition. Based on operational experience, model test results, and the physical aspects of the oxygen jet, it has been possible to refine the lance design to near perfection, to make it a vital link in the oxygen steel process.

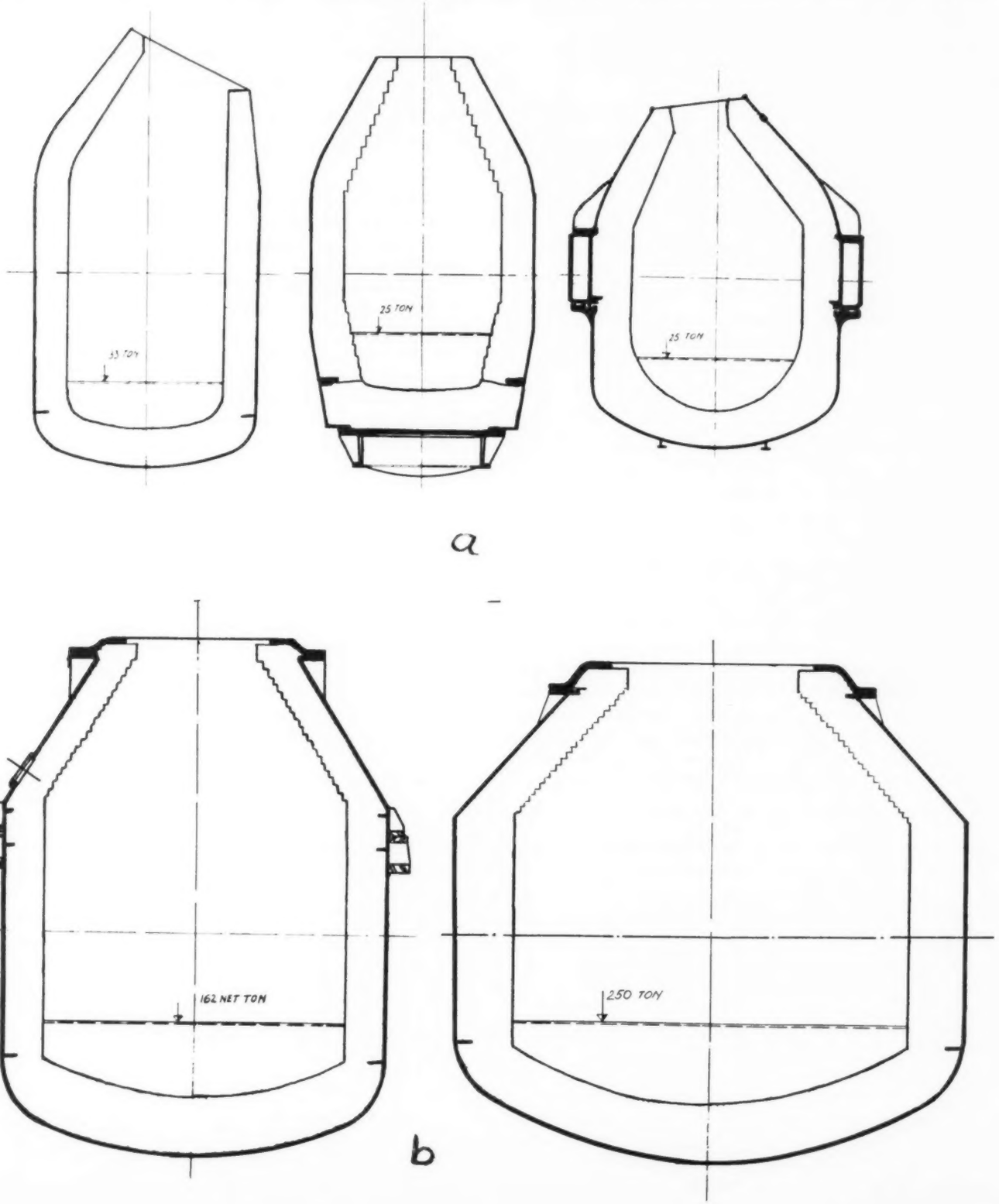
Substantial increases in O_2 flow rates and refining rates have been made—most of them at Jones and Laughlin's oxygen steel plant at Aliquippa. J&L was the first to change the usual blowing operation significantly by increasing the oxygen flow rates to 8,400 scfm while refining at 5½ tons per minute. These changes have lead to new concepts in furnace shapes to use these high blowing rates effectively. Increasing lance tip to bath distance for optimal blowing results causes the impact diameter of the jet on the slag and metal surface to increase, requiring larger diameter

furnaces. Taking this into consideration (Figure 3), dimensions for new furnaces should be determined by the expected blowing rate. Therefore, furnaces of the future should not only be designed to accommodate a certain batch size, but rather to consider the volume of oxygen that may eventually be blown.

Increasing the O_2 flow rate in existing furnaces has resulted in higher production rates. At the same time, however, refractory consumption has increased and percentage yield has decreased. Economic limits of yield and refractory use will therefore control blowing rates in existing furnaces. The oxygen furnace as designed today (Figure 1b), is capable of blowing 10,000 to 15,000 cfm, and in some conditions even more.

Tests, such as blowing hot air against a glycerin bath where the walls consisted of stearin wax, were undertaken to evaluate further lining wear of various

Figure 1 — Sections show development of top blown oxygen converter for best production and minimum refractory wear.



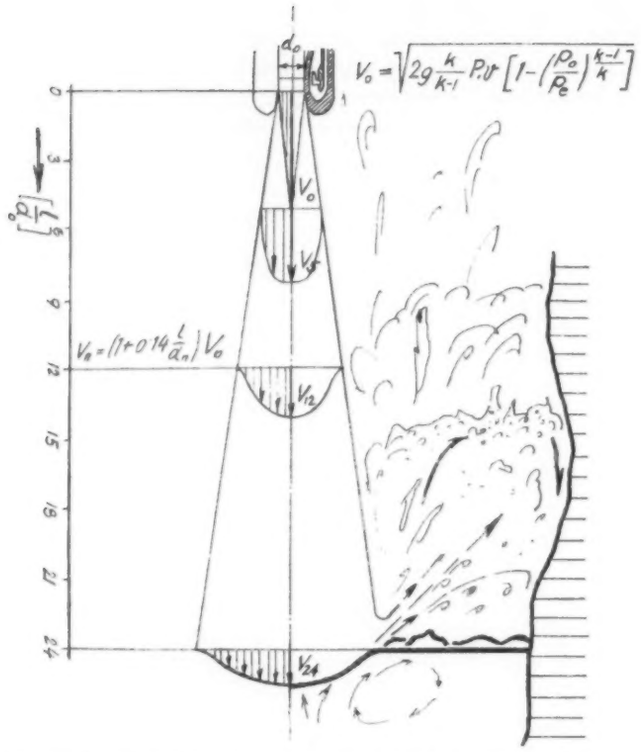


Figure 2 — Jet characteristics vary with distance of lance above the bath. Much research has been done on this phenomena.

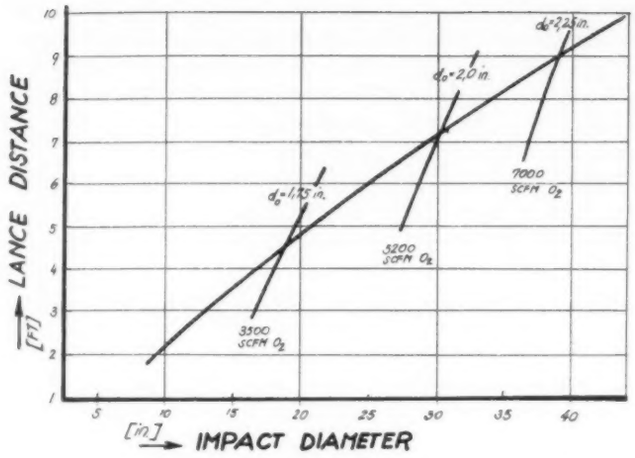


Figure 3 — Oxygen flow should be basic criteria for establishing converter size.

furnace shapes. Conditions in scale model tests have correlated accurately with the performance of full size furnaces. For example, studies were made of the appearance of skull on the furnace nose, as related to the nose brick angle. In some cases, the skull mushroomed out of the nose, while in others it built up within the interior lip area.

Comparing the newer oxygen steel furnaces with previous designs, particularly with the slender L-D converters, it will be noted that the height-to-diameter ratio has decreased. Although the bath area increased tremendously, the ratio of bath-surface to ton-of-yield has remained about the same, around 1.5 sq ft per ton of steel. Oxygen steel furnaces with large bath areas, as compared to open hearth furnaces, have shown that the ratio of surface to ton-of-steel is still four times less than open hearth practice. See Table I.

Large oxygen steel furnaces promise savings in steelmaking costs as well as reduced installation costs, compared to multiple small furnaces. The optimum furnace size depends on plant layout, and production programming of the steel mill. Any increase in bath size can only be justified if the refining speed can be increased in proportion. If this does not occur, two small furnaces will produce more steel in the same amount of time as the single large one. Generally, the reduced blowing time experienced when applying high oxygen flow rates in a properly designed furnace increases refractory life, since the lining is not exposed to heat attack for so long a period of time.

The mechanical construction of large oxygen steel furnaces presents no problem. However, thorough consideration should be given to proper utilization of the steel mill equipment. The big advantage in oxygen steelmaking over the open hearth process is that auxiliary equipment, such as cranes, charging and pouring facilities are engineered as one coordinated operation. With large open hearths, existing plant equipment cannot be utilized to best advantage because delay times occur on cranes and pouring and charging equipment. Therefore, the point of diminishing returns on installation cost is reached when installing a furnace beyond economical limits. The same holds true of open hearth shops. In order to make

TABLE I

Comparison Chart—Typical Dimensions Top Blown Oxgen Converters

Furnace	A	B	C	D	E	F	G
Capacity, tons	35	38	81	33	95	200	250
Height (H), ft-in.	22-2	24-2	24-8	19-0	22-8	27-10½	26-5½
Diameter (D), ft-in.	13-9	13-0¾	18-0	14-6½	17-6	21-8½	28-5½
(H/D), Height/diam ratio	1.61	1.84	1.37	1.35	1.28	1.28	0.93
Bath diam (d_n), ft-in.	7-10	8-6	12-6	9-1	12-6	16-4	22-0
Bath surface, (O) sq ft	48	57	125	65	122	208	380
Bath height (h), in.	44	39	47	35	56	63	52
(d_n/h), Bath diam/bath height ratio	2.12	2.65	3.14	3.28	2.7	3.15	5.1
O/volume, Bath surface/volume, 1/ft	0.31	0.33	0.33	0.44	0.34	0.22	0.33
Total vol/ton cu ft/ton	27.7	28.7	26.6	29.8	23.3	25.8	27.3
Bath surface/ton, O/ton sq ft/ton	1.4	1.5	1.55	2.0	1.3	1.05	1.5
Oxygen flow/impact area, $O_2/d_i^2\pi/4$ scfm/sq ft	3500	5200	2100	3800	3400	2000	1700
Nose diam, ft-in.	3-4	4-7	5-10	3-4	9-0	7-0	9-3
Nose speed, fps	40	45	40	40	13	38	33
O_2-flow (scfm)	2800	3000	7200	3000	4200	10,000	15,000
Impact diam (d_i), ft-in.	1-0	0-10	2-1	1-0	1-3	2-6	3-4
d_n/d_i	7.8	10	6	9	10	6.6	6.7

the best use of plant equipment, huge crane capacities usually provide slower hoisting and traveling speeds, and the equipment utilization has to be correlated and lined up with the proper number of furnaces and the most favorable furnace capacities. Small oxygen steel furnace installations are well justified in any case for producing alloy grades of steel, or for plants with smaller ingot sizes and program capacities.

There is great interest in this country in melting a higher percentage of scrap in oxygen steel furnaces. This may involve fuel additions to the oxygen stream which will result in still newer concepts of oxygen furnace design.

At present major efforts are being made to determine maximum refining speed and minimum refining time, in the interest of maximum economy and maximum production.

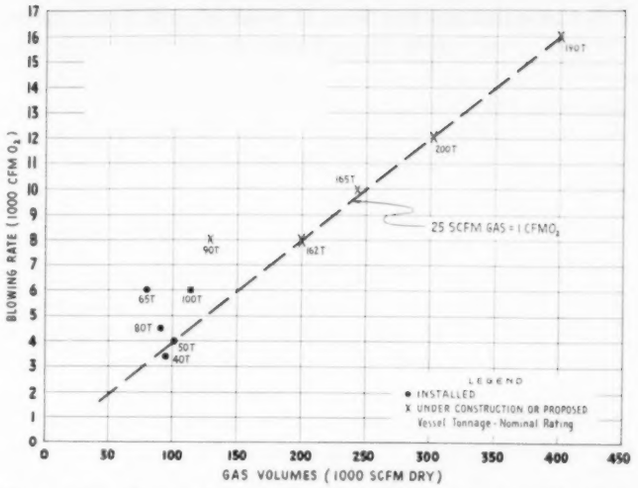


Figure 1 — Curve shows that gas volume averages 25 times oxygen volume.

GAS CLEANING

by R. G. GAW
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THE use of oxygen in steelmaking processes to speed up bath reactions greatly increases the dust and fume generation. The increase in dust and fume generation is almost directly in proportion to the rate of increase of the bath reactions.

In the basic oxygen furnace where direct high velocity oxygen jets impinge on the surface of the vessel a fume problem is created that, in all but the most remote localities, requires the application of gas cleaning equipment. To properly design and apply dust cleaning equipment to this or any process, the conditions and volume of the gases and fumes generated must be understood.

REACTION PRODUCTS

Impinging on the surface of the molten bath the oxygen reacts with metal to form FeO and, as the reaction develops, CO is formed and evolved at the reaction zone. The violence of the reaction and evolution of CO causes this gas to entrain and carry out extremely small particles of iron and other oxides. These gases, principally CO, arising from the vessel mouth at extremely high temperatures, are combined with outside air and burned. Typical analysis of gases and fume from the converter after ignition are:

Gas		*Dust*	
Co_2	0.7–13.5	FeO	1.5
O_2	11.1–20.0	Fe_2O_3	90.0
N_2	74.5–78.9	Mn_3O_4	4.4
CO	0.0– 0.3	SiO_2	1.25
Ill.	0.0– 0.2	CaO_2	0.4
H_2	0.0– 0.4	Al_2O_3	0.2
		P_2O_5	0.3

The dust, analysis of which is shown above, is principally iron oxides which are extremely fine and have a particle size analysis in percentage by weight of:

Less than 0.5 micron	= 20
0.5 to 1.0 microns	= 65
1.0 to 15 microns	= 15

To appreciate the fineness of this fume, it can be compared with tobacco smoke which has a particle size in the range of 0.5 micron. The few relatively large particles that are carried out the vessel by the high gas velocities pose no collection problem as they can be easily caught, as will be shown later in this discussion.

The total weight of the dust evolved during a heat has been found to vary from 1 to 2 per cent of the metallic charge weight. This dust loss can greatly vary, depending upon the design and operating practice for a given vessel. Thorough analysis of the design and blowing practices for existing vessels is leading to improvement in the art that will minimize this metal loss.

GAS VOLUME

It has been found that the gas volume of a dust collection system is directly related to the blowing rate and not to the nominal tonnage rating of a vessel. Since the raw gases evolved at the vessel mouth must be properly mixed and totally burned to eliminate any possible presence of CO in the flue system and thereby create a potential explosion hazard, air greatly in excess of theoretical combustion requirements is used. It is also desirable to maintain this excess air to control the temperature of the combustion products within the maximum working ranges of the materials used in the fabrication of the hoods and refractory lined flues.

By plotting the design O_2 blowing rate versus exhaust gas volumes for systems now in service and those proposed or under construction, the result is a design volume rating of 25 scfm of waste gases per cfm of O_2 blown is the general practice. See Figure 1. This ratio of exhaust gas to oxygen is particularly true for electrostatic precipitator installations where all possibility of presence of CO must be minimized. For scrubber applications a lower ratio of 20 to 1 has been used. In two known cases where lower dilution ratios were used for design

of the exhaust system, it was found that these systems could not properly handle increased gas volumes resulting from higher than design blowing rates. When designing gas cleaning systems for oxygen converters, full consideration should be given to reserve volume capacity to accommodate future increases in blowing rates.

DUST LOADING

The actual dust loading per cubic foot of gases at the vessel mouth cannot be readily measured because of the extremely high temperature. The dust loading is therefore determined at a point in the system after combustion and dilution. Expressed in grains per standard cubic foot of combustion and dilution products, this loading varies during a heat from 0 to 20. For design purposes a value of 7 to 9 grains per standard cubic foot average for a heat is normally used. The accepted steel industry practice is to reduce the dust concentration in the gases to 0.05 grain per scf; or better, at the outlet of the system. This requires a gas cleaning system with a 99.3 to 99.45 per cent minimum collection efficiency. Expressed in terms of gas at stack conditions, an 0.05 standard loading is equivalent to 0.0465 grain per cubic foot at 100 F, or 0.0260 grain per cubic foot at 500 F. It can be seen from the above that it is desirable from a visibility and dust concentration standpoint to exhaust the gases at the highest possible temperatures.

WET COLLECTION SYSTEMS

Wet collection systems installed and in operation on converters on this continent are of two basic types, thiesen disintegrators and venturi scrubbers. Of the two the venturi scrubber has found better acceptance and is in service on six vessels at three converter shops, whereas the disintegrator has been applied to only one shop.

The venturi scrubber cleaning principle is based upon acceleration of the gases and dust to high velocities in a venturi throat constriction at which point the gases and dust impinge upon large quantities of water which have been injected at right angles to the gas flow. The impact of the gas and dust on the water causes extreme turbulence and subsequent wetting and agglomeration of the dust. The wetted and agglomerated dust is removed with the excess water. Because of the extreme fineness of the dust particles produced in an oxygen converter, a single stage venturi does not obtain the high efficiencies required unless operated at extremely high pressure drops. To offset this disadvantage, a secondary venturi or scrubber is usually employed for further cooling and scrubbing. Final elimination of the dust agglomerates and entrained water droplets as accomplished in a system of this type by passing the gases through a moisture separator where cyclonic and centrifugal action throws out the large particles. The excess water not evaporated in cooling the gases containing the collected dust is run back from the venturis and moisture eliminator to a settling tank for clarification. After clarification the water is pumped back through a recirculation system for reuse. In remote localities where stream pollution is no concern the thickener underflow or sludge can be dumped to drain, but in general it must be further processed by use of vacuum filters of a design similar to those employed in blast furnace filter practice. Because of the fineness of the sludge particles greater filter areas must be considered than for equivalent quantities of blast furnace sludge. The end product, filter cake, containing approximately 20 per cent water is either further processed or dumped depending upon existing plant facilities for handling filter cake.

The schematic flow diagram (Figure 2) has been developed to illustrate a two-stage venturi scrubber cleaning system for a two converter shop generating

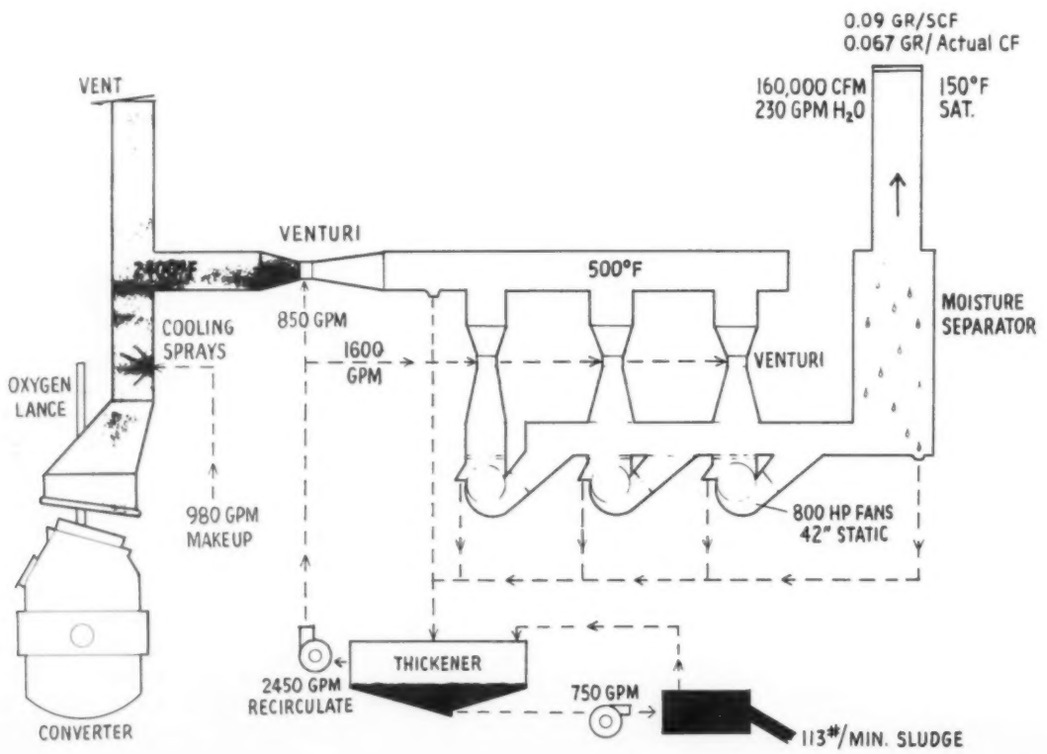


Figure 2 — Schematic shows venturi scrubber design for 80-ton vessels using 6000 cfm O_2 and designed to handle 115,000 scfm of gases with a loading of seven grains per cu ft at 98.7 per cent efficiency.

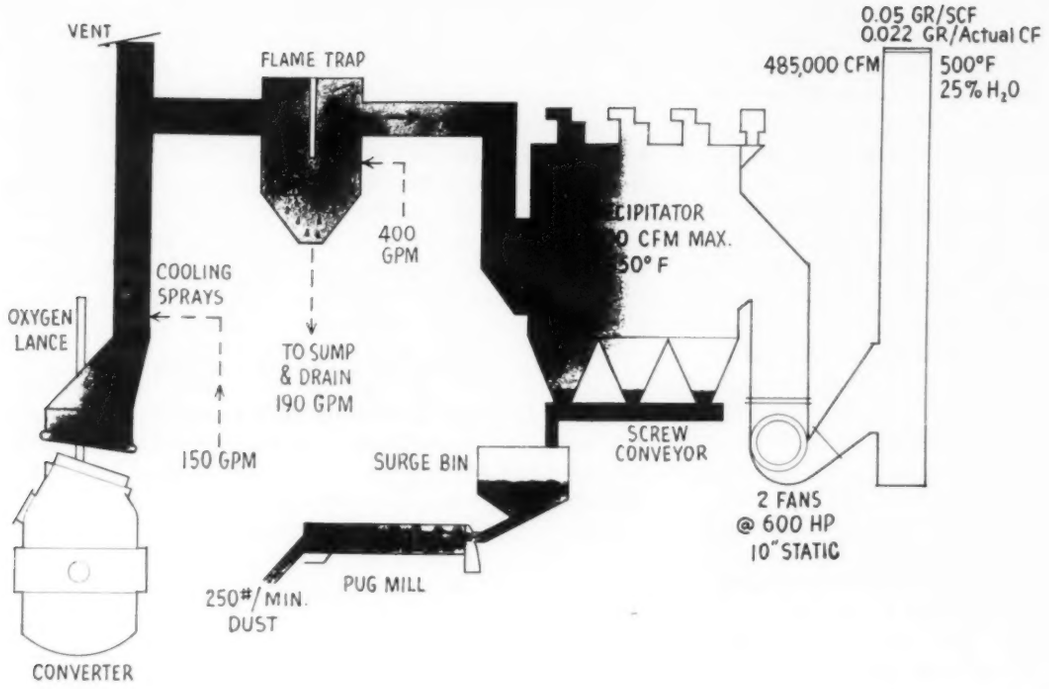


Figure 3 — Schematic shows electric precipitator design for 160-ton vessel using 8000 cfm of oxygen to handle 210,000 scfm of gases with a dust load of seven grains per cu ft at an efficiency of 99.3 per cent

gases from a 100-ton converter blowing 6000 cfm of oxygen. This system when cleaning 115,000 scfm of gases containing 7.0 grains per scf of dust requires a system pressure drop of approximately 42 in., H_2O, 37 in. of which is for the venturi scrubbers. The remaining 5 in. is required for conveying the gases. Optimum gas cleaning efficiency at stated conditions is 98.3 per cent. Any increase in collection efficiency for a system of this type can only be obtained by an increase in pressure drop, which in effect is increased operating costs.

At 37 in. venturi drop, the required installed fan horsepower is 15 hp per 1000 cfm of gases handled at stack conditions. Assuming that full energy for the scrubbers is used only during the blowing period of the heat and that savings can be realized by throttling back the fans during the idle periods, the power cost for operating fans on such a system is approximately $348.00 per day. In terms of cost per ton of steel produced at nominal vessel ratings the fan power cost is 9¢ per ton.

DRY ELECTROSTATIC PRECIPITATOR SYSTEM

Dry electrostatic precipitator systems are installed and in service at J&L, Aliquippa; Kaiser, Fontana; and Acme, Chicago, with systems of this type now under construction for J&L, Cleveland and C. F. & I, Pueblo. At least three other shops planning the use of dry precipitators are in engineering stages of construction.

Collection of converter dust and fume by dry plate electrostatic precipitators is accomplished by cooling the gases below 500 F by water sprays in the flues and spark box. At the spark box any large particles fall out either due to change in direction of the gases or from low velocity and are carried off to a sump where they are separated from the water and disposed of. The dirty cooled gases then enter a precipitator and at low velocities they are subjected to a high voltage electrostatic field where ionization of the dust particles cause them to migrate and be collected on grounded collection plates. The dust is then removed from the plates by mechanical means, generally rapping, and is made to fall into hoppers. This dry dust is removed continuously from the hoppers by screw or other type conveyors and discharged into storage bins. During day turn this stored dry dust is fed into a continuous pug mill to be mixed with about 12 per cent water by weight to a material which when properly pugged is neither sticky when handled or dry enough to be reentrained into the air to create a nuisance.

The dry electrostatic precipitator dust collection system as shown on Figure 3 for a 160-ton converter blowing 8000 cfm of O_2 is designed to clean 210,000 scfm of gases from 7.0 grains per scf to an outlet of 0.05 grains per scf for a 99.3 per cent efficiency. At actual stack conditions the outlet grain loading is 0.021 grain per cu ft.

The pressure drop required for this system is approximately 7 in. Here again if it is assumed that full fan power is required only during the blowing portion the heat, the power cost to move the gases is approximately $125.00 per day or 3.3¢ per ton of steel produced.

Questions have always been asked as to type of precipitator control and the amount of attendance required to maintain the power input into the precipitator at optimum performance. The modern rectification and control of alternating to direct current power for precipitator energization is now generally accomplished by completely sealed silicon rectifiers requiring no maintenance. Optimum power input from this type rectifier is regulated by completely automatic saturable reactor controls. Properly designed controls are tubeless with fully static devices of indefinite life requiring no maintenance or attendance.

INSTALLATION COSTS

It is most difficult to generalize on the installation cost of a dust cleaning system for a converter shop as the total cost of a system is governed more by the shop

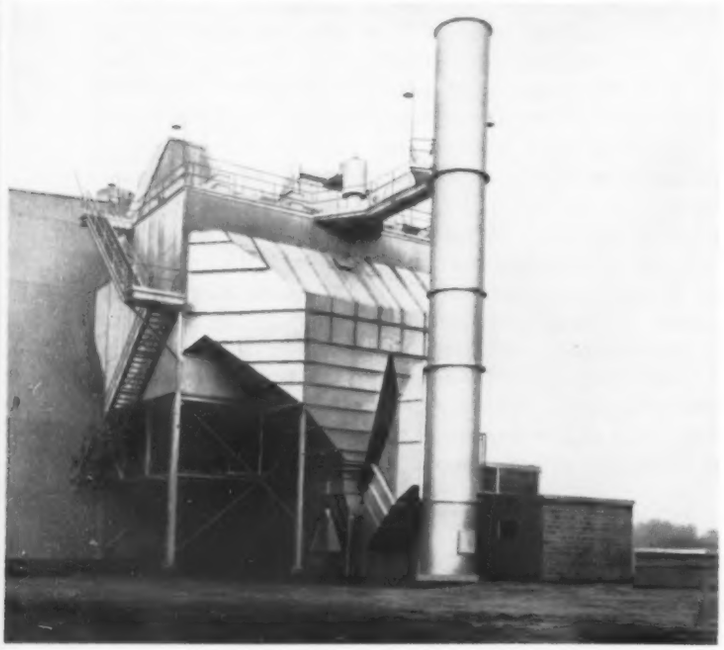
arrangement than by the variation in the actual cleaning equipment. The distance required for flue runs to the cleaning equipment, the location of the cleaning equipment, elevation of mounting whether at ground level or on top of the converter building, method of dust handling, etc., are all big factors in establishing the total costs.

For comparative cost purposes one can take a hypothetical case of a shop comprised of two 160-ton vessels, designed for only one to be blown at any one time with 8000 cfm of O_2. The vessel hood is not considered as part of the cleaning system since its design and arrangement is closely related to the vessel operation and as such is part of the steel producing equipment. Similarly the support for the flues, flame trap and other auxiliary equipment within the converter building are considered part of the building design and their costs are not included here.

For an electrostatic precipitator system designed for 99.3 per cent efficiency when handling 510,000 cfm at 550 F complete with dry dust handling storage and pugging, all mounted at ground level external to the converter building, the approximate cost will vary between $3.50 to $4.00 per cfm of gases handled at precipitator conditions. Analysis of these costs would show that the precipitator with its energizing equipment and controls would amount to 35 to 40 per cent of the total cost of the system. Of the remaining costs the flue, stack and fan systems would account for the major portion.

A venturi scrubber installation for a shop with the same vessel size and blowing rate could be designed to handle 215,000 cfm at 150 F with a gas cleaning efficiency of 98.7 per cent when utilizing a pressure drop of 42 in. H_2O. First review of a scrubber system with lower gas volumes at stack conditions than for a dry precipitator would lead one to believe that there should be considerable savings in installation costs. However, when critically analyzed it becomes apparent that although the flue sizes are considerably smaller, this reduction in flue size is offset by increased costs for larger fans and water pumping and handling equipment. In addition, the wet dust handling system comprised of thickeners, filters, sludge handling and a water recycle system is considerably more expensive than for the dry precipitator dust pugging system. Best available figures indicate that the total cost of a wet scrubber designed for identically sized vessels and blowing rates would be approximately the same as for a dry precipitator system.

Figure 4 — Precipitator installation at new plant of Acme Steel Co.



OPERATING AND MAINTENANCE COSTS

Again using the 160-ton vessel with 8000 cfm blowing rate as a basis for comparison and assuming 350 days per year operation with the actual blowing period as 50 per cent of the total elapsed time, one can compare the operating costs for each system.

Wet Scrubber—Series venturi with 42-in. drop

	Hour	*Year*
Fan power, 1450 kw @ 1¢	$14.50	$122,000
Water pumping power, 306 kw @ 1¢	3.06	25,800
Misc power cost, 75 kw @ 1¢	0.75	6,300
Operating labor, 1 man 24 hr per day	4.00	32,500
Maintenance, 4% per yr of total cost	—	70,000
Total cost	$22.30 per hr	$256,600 per yr
Cost per ton	0.14¢	

Electrostatic Precipitator

Fan power, 520 kw @ 1¢	$ 5.20	$ 43,700
Rectifier power, 250 kw @ 1¢	2.50	21,900
Water pumping and Misc. power 120 kw @ 1¢	1.20	10,000
Operating labor, 1 man 24 hr per day	4.00	32,500
Maintenance, 3% per yr of total cost	—	52,500
Total cost	$12.90 per hr	$160,600 per yr
Cost per ton	0.08¢	

The costs outlined above do not include either the cost of disposal or return from the use of the dust. Up to 94 tons per day of dry dust equivalent must either be disposed of or utilized. The filter cake because of its state can only be practically utilized as a sinter mix addition. The dry dust on the other hand can be further processed at a nominal cost per ton to a material whose value would be approximately $15.00 per ton. The utilization of the dry dust would more than pay for the operating and maintenance cost of the precipitator system.

ADVANTAGES AND DISADVANTAGES OF THE TWO SYSTEMS

Before attempting to evaluate either system it should be pointed out that any dust collection system must in no way hinder the converter production.

WET SCRUBBER SYSTEM

Disadvantages

1. Higher operating cost.
2. Disposal and handling of the sludge.
3. Maintenance of the system—problems with deterioration and maintenance are inherent in systems handling saturated gases.
4. Steam plume from stack. Although a clear stack from a dust standpoint may result, a very noticeable steam plume is present during cold weather as the gases discharged are saturated with water.
5. Mudding of fans. At least one existing installation reports fans must be cleaned every two weeks to offset unbalance due to mudding.
6. Less effective cleaning. In terms of the weight of dust per cu ft of gas at actual stack conditions, the scrubber loss is much higher than for a precipitator. This greater loss is due to the much lower operating temperature of the scrubber. In order to obtain outlet dust loadings equivalent to the precipitator system, pressure drops in the range of 50 to 60 in. would be required.
7. Hood life. Since less volume of air used is for the system the waste gas temperatures at the hood are higher and therefore hood life may be decreased.
8. Recovery value of dust. Dust collected in the wet system cannot be further processed economically. Therefore the possibility of recovering operating and maintenance costs for this system does not seem likely.

Advantages

1. Smaller space. Requires less space than precipitator system.
2. Gas volume. Since gases are not subjected to electrical charge smaller gas volumes may be exhausted without danger of explosion due to presence of CO.
3. Installation cost. If sludge may be dumped to drain without clarification, initial installation cost may be lower than precipitators for equivalent sized vessels.

DRY PRECIPITATOR SYSTEM

Disadvantages

1. Space. Requires larger space than scrubber installation.
2. Gas volume. Requires larger gas volume than those exhausted by venturi since presence of CO in combustible mixtures cannot be tolerated.
3. Gas temperature. Exhaust gas temperatures in excess of 650 F cannot be tolerated because of physical limits of equipment.
4. Saturated gases. Saturated gases cannot be handled in system since condensation and mudding within the precipitator would cause problems in removal of dust.

Advantages

1. Operating cost. Since precipitators require only 1 to 2 in. pressure drop considerable saving is realized in fan power cost.
2. Flexibility of operation. The pressure drop through precipitators does not appreciably increase if volume is increased. If the system is designed for multiple unit precipitator operation, one precipitator unit may be taken off the line for maintenance without reduction of gas volume exhausted from vessel hood.
3. More effective cleaning. With the gas exhausted at high temperatures the actual outlet dust loading in terms of grains per cu ft at stack conditions is much less than for scrubbers operating at low temperatures. If efficiencies of 99.9+ per cent are required these can be obtained by additional precipitator capacity without sacrificing the inherently low power cost of the system.
4. No excessive steam plume. Gas exhausted at high temperatures are not saturated and therefore no serious steam plume exists.
5. Ability to by-pass gases. If emergency arises, uncleaned gases may be by-passed without fear of damage, plugging or excessive power cost to the system.
6. Recovery value of dust. Properly pugged dust is more suitable for use as addition to sinter mix or for further utilization than wet filter cake which is hard and uneconomical to handle.
7. Elimination of potential stream pollution problem.

OPERATIONS

by D. W. SMITH
General Foreman,
Basic Oxygen Furnace Plant,
Jones & Laughlin Steel Corp.,
Aliquippa, Pa.

THE basic oxygen furnace plant at Jones & Laughlin's Aliquippa Works started operations on November 11, 1957. This plant was the second plant of its type to be constructed in the United States and the third on the American continent. Since this date, three additional plants have started operations, one in Canada and two in the United States. In addition, basic oxygen steelmaking facilities are being planned or seriously considered by numerous steel producing concerns in the United States. The primary reasons re-

Figure 1 — Production increased steadily after start of the converter at the Aliquippa Works.

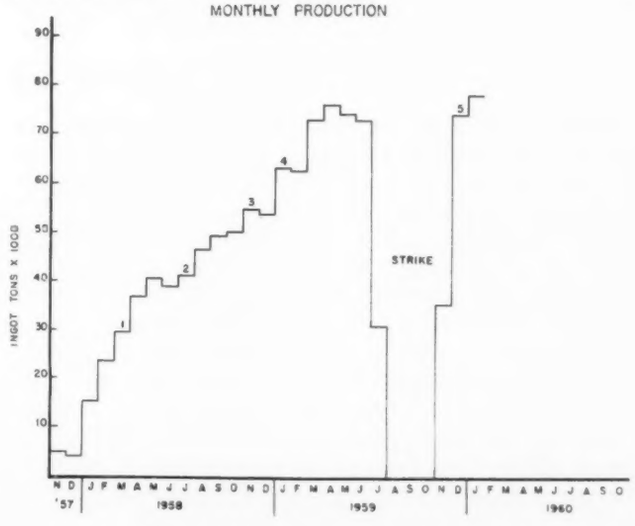


Figure 2 — Four scrap charging boxes are mounted on each car.

Figure 3 — Charging ladles have 80-ton capacity.

sponsible for the rapid expansion of this new steelmaking process are: (1) relatively low capital investment costs as compared to other conventional steelmaking processes; (2) the recent availability of large quantities of high purity oxygen at economically feasible rates; (3) extremely high rates of productivity with accompanying lower conversion costs; and (4) steel quality equivalent to or superior to that of steel produced by other processes.

The general plant layout includes a scrap handling aisle, a charging aisle, a service aisle on the tapping side of the furnace, a teeming aisle, and an electrostatic precipitator. Oxygen generating facilities, of 230 tons per day capacity, are within plant confines, but are owned and operated by the oxygen producer. The designed capacity of the basic oxygen plant called for a monthly production of 63,000 tons producing 54-ton heats, an annual production of 756,000 tons. Current operating rate indicates an annual production of 900,000 tons or 75,000 tons per month; producing 82-ton heats.

The purpose of this paper is to describe briefly some of the equipment directly related in the production of a heat and to outline the production rate and heat cycle that has been achieved to date. Proposed heat cycles and production rates for larger heats will be discussed.

PRODUCTION

Many of the problems encountered in bringing a basic oxygen steel plant to full capacity are common to all types of steelmaking; others, however, are peculiar to this type of process.

The initial operations for a period of two weeks consisted of one turn per day. As rapidly as possible, new personnel were trained and the rate of operations extended to two turns per day. After ten weeks of operation, it was possible to schedule plant operations for three turns per day. Since February 1958, the plant has operated seven days each week, except for one downturn for planned maintenance repair work every other week.

The production of the Aliquippa plant has increased from a quite modest beginning of 5,137 tons for the month of November, 1957, to a record monthly production of 77,128 tons for January, 1960. Figure 1 is a graph showing the monthly production from startup to date. Significant changes in operational practice, design features, and additional facilities which have contributed toward increased productivity are shown on the graph as Nos. 1 through 5. These changes are as follows:

No. 1. In March of 1958 a transition began from 54-ton heats to 81-ton heats. Transition completed in May, 1958. The change to the larger heat size required revisions of teeming ladles. More recently by adding an increment of 27 tons, 108-net ton heats have been produced experimentally.

No. 2. In August, 1958, changes were made in lance nozzle design which permitted an increased oxygen flow rate and reduced the refining time. During the first few months of operations, 54-ton heats were refined in approximately 26 min with an oxygen flow rate of 3800 cfm. The original lance nozzle design was changed and by using a larger nozzle orifice, the refining time has been gradually decreased to slightly over 20 min for an 82-ton heat using an oxygen flow of 6500 cfm.

No. 3. In November and December of 1958, new water-cooled hoods of paneled construction were installed over the furnaces to handle the effluent gases. Original hoods of solid construction gave poor service and innumerable production delays were encountered to repair water leaks in these hoods. Since the installation of the new hoods, delays due to leaks have been negligible.

No. 4. In January, 1959, management established an equipment utilization incentive program for the plant. The program was well received by the men and proved to be a great impetus to production.

No. 5. In the latter part of December, 1959, operations started in a new 180-ton per day oxygen generating plant at Glassmere, Pa. This has permitted a full and adequate oxygen supply for steel production at the Aliquippa plant. This year to date no delays have been experienced as a result of limited oxygen supply.

Figure 4 — Trials have been made with oxygen flows up to 8200 cfm.

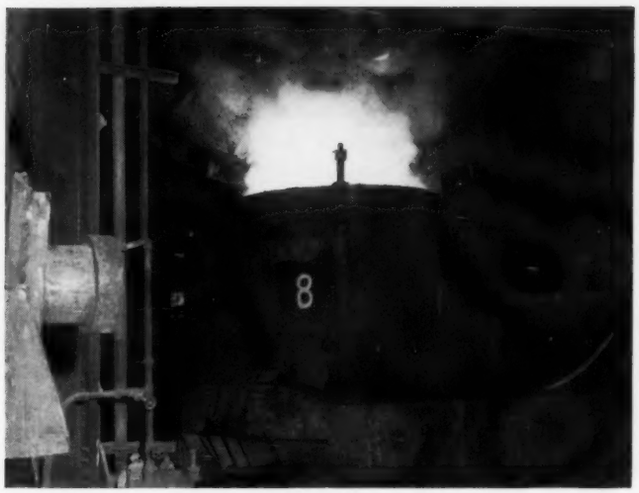


Figure 5 — Tapping time runs about four minutes.

HEAT CYCLE AND EQUIPMENT

Before getting into the mechanics of the phases required in producing a basic oxygen heat it is only proper to first describe the furnace itself which is the heart of the operation. The furnaces, two in number, have a nominal rated capacity of 65 tons. Heats up to 108 tons have been produced satisfactorily, but limitations with some of the equipment prevent going to this size heat currently. The present standard heat size is approximately 82 tons. Only one furnace is operated while the other is off for relining.

The shell of the furnace is of two-piece construction with maximum inside diameter of 17 ft-8 in. and a height of 22 ft-4 in. The bottom section, which is dished in shape is welded to the center section. The eccentric cone section is bolted to the center section and can be readily removed if desired. Plate, 1½ in., is used in the cone and bottom, and 2-in. plate in center section. This shell weighs 116 tons, and the lined weight is approximately 280 tons.

The furnace is supported by a box type trunion ring consisting of 1½-in. thick web plates with a 6-in. top and bottom flange. Weight of this trunion is 80 tons and is designed so that the furnace can be rotated through 360 degrees.

The furnace drives consist of speed reduction gears and couplings. There are two d-c drive motors of 130-hp capacity for each furnace, either one of which is capable of rotating the furnace under normal conditions.

Heats are tapped through a 5-in. diameter tap hole in the cone section of the furnace. Each furnace is equipped with an electrically driven transfer buggy which moves teeming ladles between the service or tapping aisle and the teeming aisle.

The most important feature of the basic oxygen furnace operation with respect to production rates is material handling. To achieve full production capacity from heat to heat, hot metal, scrap and fluxes must be available for charging at a time schedule based on minutes.

The first phase of making a heat is the charging of scrap. Scrap is charged into the furnace from charging boxes tilted by hydraulic cylinders, and mounted on a frame carriage which operates on a track system from a scrap loading platform to the charge side of the furnace. Capacity of each of the four boxes mounted on the car is 15,000 lb of scrap with an approximate density of 125 lb per cu ft. The scrap car is moved with an electric mule. The average weight of scrap for a 92-ton charge is 55,000 lb, and requires 2.39 min for charging. Figure 2 shows the scrap charging operation. The loading of scrap boxes on the scrap charger for the next heat is started as soon as possible. The proper amount of scrap for the charge is usually not determined until a bath temperature has been taken on the previous heat, since the proportions of scrap and hot metal have a major influence on metal end temperature. A slight adjustment in scrap weight may be necessary while the furnace is being tapped, then the scrap car is moved into charging position.

Hot metal is delivered to the plant in 190-ton mixer ladles and is withdrawn directly into the charging ladle, placed on scales in a reladling pit. Charging ladles are 80-ton capacity and are handled by an overhead crane. The proper weight of hot metal for the charge is determined at the same time the scrap weight is established. Mixer ladles that do not contain sufficient metal for a full charge are drained out and replaced during the processing of the previous heat. The charging ladle is moved to the furnace while the previous heat is being tapped and hot metal is available immediately for charging following the scrap. An average hot metal addition of 130,000 lb requires an average time of 2.68 min for charging. Figure 3 illustrates the charging of the furnace with hot metal.

After the hot metal is charged the furnace is rotated into the vertical position, the oxygen lance lowered to a predetermined position of from six to nine ft above the bath level, the lance clamps are set, and the flux chute positioned over the top of the furnace. This period of preparing for oxygen requires approximately 1.78 min.

The flux charge, consisting of lime, fluorspar and mill scale, are ordered considerably in advance of charging and are available when required. Fluxes are charged into the furnace from a larry car located on the floor above the furnace. On verbal instructions from the furnace operator, by an intercommunication

system, the larry car operator dumps the flux into the additive chute. Since the flux is added shortly after ignition occurs between the oxygen and the metal bath no additional time is required in the over-all heat cycle.

The phase of operations that consumes the major portion of the total heat cycle is the furnace refining time. In the basic oxygen process this may be termed as lance time, or the interval during which the lance is lowered over the bath, and a stream of oxygen at predetermined flow rates is directed at the metal bath. As previously mentioned with original lance design and oxygen flow rates of 3800 cfm, 54-ton heats were refined in 26 min. After transition to 82-ton heats, a refining time of 34 min was required using this same flow rate. By changing the lance design and increasing the diameter of the nozzle orifice, the lance time has been reduced to 20.22 min using an oxygen flow rate of 6500 cfm. Trials using lances with an even larger nozzle orifice and oxygen flows up to 8200 cfm have resulted in lance times of approximately 17 min. It thus appears that further reductions in refining time may be possible, although changes in nozzle design will be necessary to avoid damage to the furnace refractories and consideration must be given to the time required to melt scrap which averages 30 per cent of the total charge. In most cases with lance times under 20 min, varying quantities of scrap are left unmelted in the furnace. Furthermore decreased refining times are of no benefit if related operations such as material handling and teeming are not geared to the same pace. Figure 4 shows the furnace during the refining of a heat.

When the lance has been removed the furnace is turned to the charging side for bath temperature measurement by a disposable tip thermocouple and the slag is inspected by the melter to see that it is properly shaped-up. The time required for this operation averages 1.82 min. If the temperature is within the specified tapping range and no tests are required, the furnace is tilted over and tapped. However, if the temperature is not within the aim range, it must be brought within range to prevent subsequent ladle skull or stool and mold stickers. Heats found to be too hot for teeming are cooled to proper temperature by small scrap additions. Cold heats are reblown from one to three minutes to increase temperature, with coke additions made before reblowing. The average time per heat required for temperature adjustment is 5.46 min.

When the temperature is within aim range, the furnace is rotated to the tapping side and tapped, the tap requiring three to 5 min, the average being 4.32 min. Proper regulation of rotation of the furnace to tap, and position of the tap hole are such that the stream is exceptionally clean. Alloy additions are made into the ladle during the tap. Only sufficient slag is added to the ladle to provide proper insulation. Figure 5 shows the tapping of a heat.

Upon completion of tap the furnace is rotated to the charging side and the remaining slag is flushed into 180 cu ft capacity slag boxes placed on slag cars. The slag car is moved in relation to the furnace tilting to completely catch all the slag in the boxes. A narrow gage diesel locomotive moves and changes slag cars under the furnace as required. The total time required for flushing slag averages 1.78 min. As soon as the slag has been removed, the furnace is rotated upward and immediately charged with scrap for the next heat.

The following summarizes the complete heat cycle as just described:

Average Heat Cycle—Jan. 1960 82-Ton Heat

Sequence	*Time, min*
1. Charge scrap	2.39
2. Charge hot metal	2.68
3. Prepare for oxygen	1.78
4. Oxygen time (6500-cfm)	20.22
5. Temperature and inspection	1.82
6. Temperature adjustment	5.46
7. Tapping time	4.32
8. Slagging off	1.78
Heat time	40.45
9. Delays	6.12
Tap-to-tap time	46.57
Production rate 106 tons per hour	

As indicated by the chart this was the average heat cycle achieved in January of this year when producing 77,128 net tons of ingots, while operating 728 hr during the month. While January represents the record in ingot tonnage, the highest production rate was established in April of 1959 when the average tap-to-tap time was 46.50 min producing 107.5 tons per hour.

The delays which averaged 6.12 min per heat during January are, for the most part, common to all other steelmaking processes. Some of these delays include repiping the tap hole, cleaning scrap off the top of the furnace, patching the furnace lining, cleaning transfer and slag tracks under the furnace, casting pit delays, and electrical or mechanical failures of essential operating equipment.

There are two definite areas in the heat cycle, as shown, where improvement is anticipated. These two areas are the time required for temperature adjustment and the delays, namely, pit delays.

Accurate control of finishing temperature is a major problem. On the average, 50 per cent of all heats are outside the specified tapping temperature range of 2880 to 2920 F, and time is consumed for corrective adjustments. After an extensive study of the thermochemistry of the process by the Jones & Laughlin research department, it was found that a mathematical approach could be used as an aid in the solution of this problem. A set of mathematical control equations was developed to determine the amounts of scrap and hot metal needed in the charge to arrive at any specified finishing temperature. The practicability of this approach has been established in recent mill trials, wherein calculated additions were charged into the furnace. The application of the mathematical equations are very suitable for adaptation by an analog computer. Arrangements have been made to obtain a computer as an aid to the melter in establishing consistent finishing temperatures. It is hoped that with the use of this computer the time required for temperature adjustment will be reduced by 2½ min per heat.

In the basic oxygen plant at Aliquippa the teeming space corresponds to the furnace operating area. The space available permits the teeming of two 82-ton heats at a single platform, teeming only one heat at a time. This space limitation creates problems in ingot mold

handling. The transition from 54 to 82-ton heats necessitated an extension of the teeming platform so that the teeming operation could be maintained without causing undue delays to the furnace operations. However, as production rates have increased additional pit delays have been encountered. Further extension of the present teeming facilities is contemplated. With the availability of increased teeming space it is anticipated that many of the pit delays will be eliminated. A reduction of one minute in delays per heat is expected.

If the aim in these two areas is realized, a reduction of 3½ min in the average heat cycle will be achieved and the tap-to-tap time reduced to 43.07 min. This heat cycle will result in a production rate of 114.54 tons per hour. This rate will produce 83,385 net tons of ingots per month operating 728 hr in the month. This tonnage represents about the maximum that can be expected from a single furnace producing 82-ton heats.

The next obvious step for increasing production rate is to increase the heat size. As previously mentioned 108-ton heats have been produced in the Aliquippa furnace. Furnace performance with this size heat was found to be satisfactory, however, major changes to many items of equipment would be required to produce 108 ton heats exclusively. The following is an estimated heat cycle which could be expected for producing 108-ton heats.

Proposed Heat Cycle 108-Ton Heat

Sequence	*Time, min*
1. Charging scrap	2.70
2. Charging hot metal	3.82
3. Prepare for Oxygen	1.78
4. Oxygen time	25.60
5. Temperature and inspection	1.82
6. Temperature adjustment	6.00
7. Tapping time	5.61
8. Slagging off	1.96
Heat time:	49.29
9. Delays	6.12
Tap-to-tap time:	55.41
Production rate 117 tons per hr	

This heat cycle is an extropolation of the cycle obtained on the 82-ton heat and is based on the assumption that larger capacity equipment can be designed to adequately handle the materials required in the operational phases of producing a larger heat. The oxygen time, or refining time, is based on a slightly accelerated oxygen flow rate over that used in producing the 82-ton heat.

The production rate of 117 tons per hour would produce approximately 85,000 net tons of ingots per month operating 728 hr in the month. This increased productivity may justify the necessary changes in equipment at the Aliquippa plant for producing such heats.

Considering that pilot scale experiments started only a little more than ten years ago, the basic oxygen process has experienced phenomenally rapid development to its present position as a mature commercial process. It has been established that basic oxygen furnace production has already achieved production rates in excess of those possible in other steelmaking methods. In addition, it is evident that the present rates will be exceeded by increases in furnace and heat size, accelerated refining rates and changes in auxiliary equipment. Installed capacity for producing basic oxygen steel in the United States is currently rated at 4,157,400 tons annually. World capacity at the beginning of 1960 exceeded 14,000,000 tons. ▲

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ASSOCIATION OF IRON AND STEEL ENGINEERS

1010 Empire Building **Pittsburgh 22, Pa.**

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Monday, November 28, 1960—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Smelting and Fabrication of Aluminum," by a speaker from Aluminum Corp. of America

Guest House Motel

BUFFALO SECTION

Tuesday, November 15, 1960—Dinner 6:30 P.M., Meeting 8:00 P.M.

"Application and Lubrication of Roller Bearings in Rolling Mill Equipment," by Paul L. Haager, Assistant Chief Engineer, Industrial Div., The Timken Roller Bearing Co., Canton, Ohio

Sheraton Hotel, 715 Delaware Ave., Buffalo, N. Y.

CANTON SECTION

Monday, November 21, 1960—Dinner 6:30 P.M., Inspection Trip 8:00 P.M.

Inspection Trip: Ford Motor Co., Forging Plant, Canton, Ohio

CHICAGO SECTION

Tuesday, November 1, 1960—Dinner 6:15 P.M., Meeting 7:45 P.M.

Welcome to Midwest Steel Night

Presidential Visit by S. C. Read, President AISE 1960.

"Exporting Jobs from United States," by William Clark, Financial Editor, Chicago Tribune, Chicago, Ill.

South Shore Country Club, Chicago, Ill.

CLEVELAND SECTION

Tuesday, November 22, 1960—Social Hour 6:00 P.M., Dinner 6:30 P.M., Meeting 7:45 P.M.

"Integrated Automation for Steel Plants," by W. M. Krummel, Steel Mill Application Engineer, General Electric Co., Schenectady, N. Y.

"The Automated Blast Furnace—Fact or Fiction," by J. E. Oram, Application Engineer, General Electric Co., Schenectady, N. Y.

Cleveland Engineering and Scientific Center, 3100 Chester Avenue, Cleveland, Ohio

COLORADO SECTION

Tuesday, November 15, 1960—Social Hour 6:30 P.M. Dinner 7:00 P.M., Meeting 8:00 P.M.

"Design and Engineering of the Basic Open Hearth Furnace," by F. F. Bach, Assistant Chief Engineer, Pueblo Plant, The Colorado Fuel and Iron Corp., Pueblo, Colo.

Minnequa University Club, Pueblo, Colo.

DETROIT SECTION

Tuesday, November 8, 1960—Dinner 6:30 P.M., Meeting 8:00 P.M.

"Selection of and Preventive Maintenance for Roll Neck Bearings," by Jas. Barnes, Superintendent Shop, Maintenance Steel Div., Rouge Plant, Ford Motor Co., Dearborn, Mich.

Dinner and Meeting—Parlors E, F, and G, Horace Rackham Educational Memorial Building.

LOS ANGELES SECTION

Monday, November 14, 1960—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

Details not available

Michaels Restaurant, Telegraph Rd. and Washington Blvd., Los Angeles, Calif.

PHILADELPHIA SECTION

Saturday, November 5, 1960—Dinner 6:00 P.M., Meeting 7:00 P.M.

"Development and Operation of Main Utility Substation at Alan Wood," by K. J. Flanagan, Project Electrical Engineer, and H. W. Vanaman, Assistant Superintendent of Power, Alan Wood Steel Co., Conshohocken, Pa.

"Some Aspects of Metallography in a Commercial Plain Carbon Steel Plant," by Arthur H. Valentine, Sr., Metallographist, Metallurgical Dept., Bethlehem Steel Co., Sparrows Point, Md.

Engineers' Club, 1317 Spruce St., Philadelphia, Pa.

PITTSBURGH SECTION

Monday, November 14, 1960—Inspection Trip 12:30 P.M., Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

Inspection Trip to Jones & Laughlin Steel Corp., Aliquippa, Pa.—Buses will leave the University Club in Oakland, Pittsburgh, Pa., at 12:30 P.M. and will return to the University Club for the dinner and meeting.

Symposium on Various Annealing Methods

"Continuous Annealing," by W. P. Gill, Specialist, Heat Processing Equipment Sales, Industrial Heating Dept., General Electric Co., Shelbyville, Ind.

"Conventional Batch Annealing," by Gerome Gordon, Vice President, Swindell-Dressler Corp., Pittsburgh, Pa.

"Open Coil Annealing," by Lee Wilson, Chairman, Board of Directors, Lee Wilson Engineering Co., Cleveland, Ohio

Dinner and Meeting, University Club, University Place, Pittsburgh, Pa.

ST. LOUIS SECTION

Wednesday, November 30, 1960—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Continuous and Semi-Continuous Casting by Direct Chill Methoo," by T. R. Dearden, Lewin-Mathis Co., Div. of Cerro de Pasco Corp., Monsanto, Ill., and D. J. Leonard, Dow Metal Products, Madison, Ill.

Elks Club, Granite City, Ill.

SAN FRANCISCO SECTION

Tuesday, November 15, 1960—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

Kaiser Steel Corp. Night

"Some Basic Questions Concerning Steel Market Gross," by B. E. Etcheverry, Director, General Planning Dept., Kaiser Steel Corp., Oakland, Calif.

Spengers Restaurant, Berkeley, Calif.

UTAH SECTION

Monday, November 14, 1960—Social Hour 6:30 P.M., Dinner 7:30 P.M., Meeting 8:30 P.M.

"Fundamentals of Refractories," A. P. Green Co.

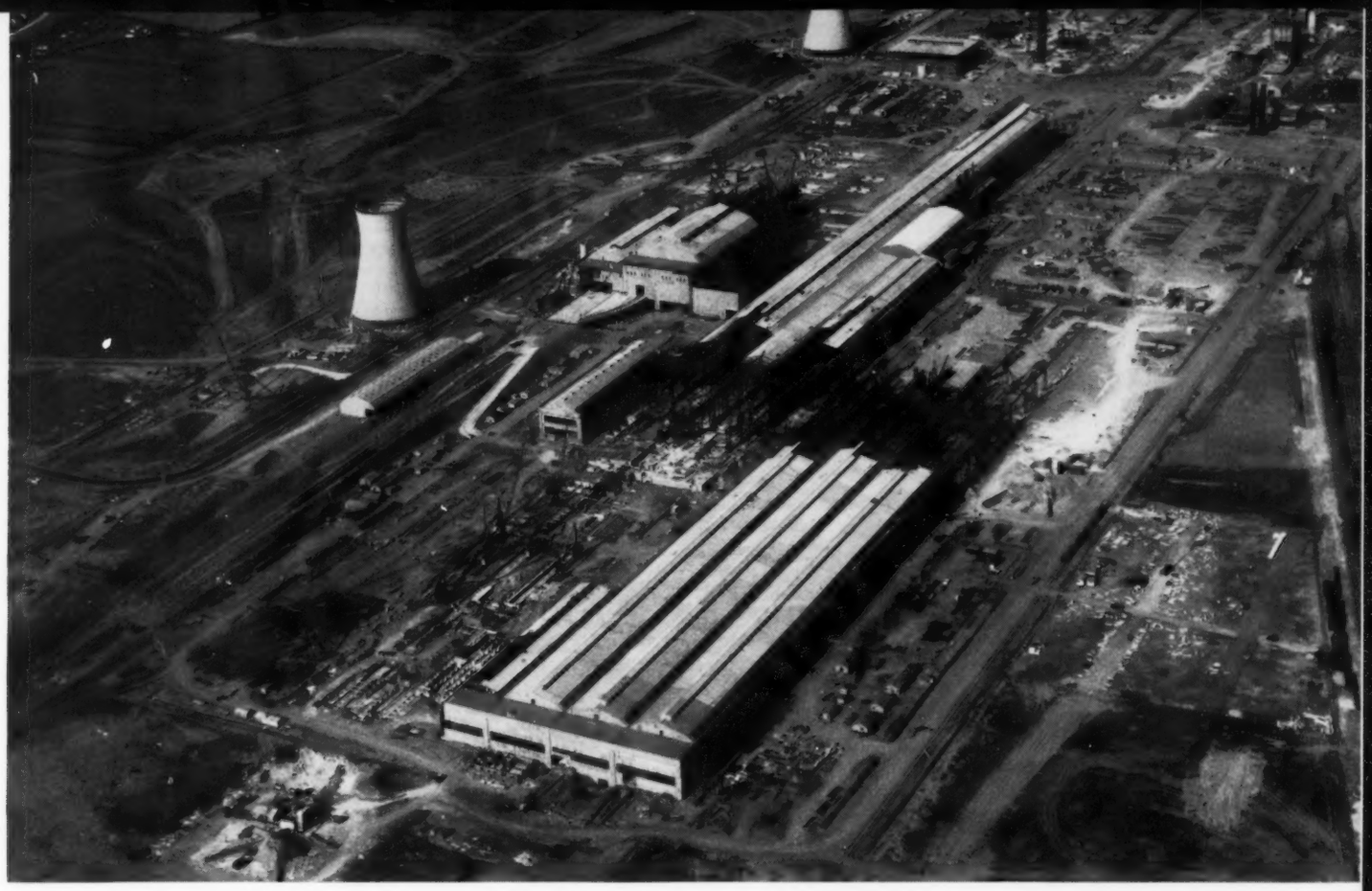
Grandview Cafe, Provo, Utah

YOUNGSTOWN SECTION

Monday, November 28, 1960—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Modern Concepts of Industrial Building Design, Heating and Ventilating," by Stig O. Forssmark, Engineer, Trygve Hoff & Associates, Cleveland, Ohio.

Mahoning Country Club, Girard, Ohio



Typical of the "green-fields" plants is South Works of the South Durham Steel and Iron Co. Ltd. at West Hartlepool, Yorkshire. It will have two large blast furnaces, five tilting open hearth furnaces and a plate mill. Steelmaking and rolling began here in August of this year.

A Look at Steel Abroad

by T. J. ESS

Foreign steel is expanding and modernizing . . . . it will offer stiffer competition to the American industry . . . . it was a privilege to see some of it, and a word of appreciation is due the managements of the companies visited for their fine hospitality.

SOME wit once said "One swallow doesn't make a spring," and certainly, visiting a few steel plants abroad does not make one an expert on the foreign steel situation. Profound deductions and earth-shaking developments are therefore not to be found in this report. Rather, it is a collection of observations resulting from visits made to 32 steel plants, machinery builders, research centers and engineering societies in England, Wales, Holland, Belgium, France, Luxembourg and Germany. The comments apply only to the visited areas, which, however, form a rather representative cross-section of the industry.

One general conclusion is inescapable. As foreign steel capacity expands—and it is doing so—American steel is not only going to lose some of its export market, but it will be faced with competition at home. Our production efficiency is not going to offset the differential in labor costs as foreign plants are modernized—and as our labor rates increase. This is a cold fact that should have the sober consideration of American managements, workers and union leaders.

RAW MATERIALS

Britain depends heavily on imported ores, which come from Africa, South America, Canada, Sweden, Spain, etc., and range 45 to 60 per cent Fe content. Some domestic ore of rather low grade is also used. Consequently, a goodly amount of ore storage is essential if the blast furnaces are to be spared constant burden changes.

In France, Belgium and Luxembourg, the industry depends principally on the vast Minette ore deposit centered in Lorraine, where 70 per cent of French capacity is grouped. This ore runs 26 to 30 per cent Fe and is high in phosphorus. Much of the ore is carried direct from the mines to the steel plants in buckets suspended on overhead cable conveyors which span the

fields and hills. Moves up to 30 miles or more are made this way.

Germany has some low grade ore (about 25 per cent Fe) but also uses a great amount of imported ores from Sweden, Labrador, Africa and South America, particularly in the Ruhr area, which accounts for about 70 per cent of the German capacity.

Most of the countries have more or less adequate coal resources but in some cases mining is expensive. Some coal seams are only two feet high. Most of Holland's coal requirement is imported.

Coke production is entirely from by-product ovens. Methods and practice seem to be similar to those in the United States. In many cases, half or more of the coke oven gas is sold for domestic use.

In some instances, a plant will have blast furnaces and no coke plant, while another will have a coke plant but no blast furnaces. Cross sales of coke, gas and iron are arranged to suit the requirements of both. It seems that government regulations make such arrangements advantageous. In some cases, the coke plants are at the coal mines under government ownership.

Charles L. McGranahan (center), technical counsellor for SOLLAC and the author's guide and mentor through France, is shown here with Messrs. Staquet and Ink, also of SOLLAC.

IRONMAKING

For the most part, the older blast furnaces are relatively small, running from 12 to 18-ft hearth diameters. The newer furnaces are larger, running 23 to 28-ft hearth diameters, with a 29.6-ft unit in Germany and a 31-ft furnace in Wales.

Some of the French furnaces use a belt of secondary tuyeres—usually half as many as there are main tuyeres—4 to 5 ft above the main tuyeres. These are used at times because of the coke quality.

Belt conveyors seem to be used for handling materials around blast furnaces to a greater extent than in the United States. At one plant, all material is brought to the stock bins by belt conveyors. In another, belts actually carry the materials to the furnace tops. One blast furnace manager thinks skips should be abolished in favor of conveyors.

Many of the blast furnaces have carbon hearth walls up to the tuyeres or to the lintel.

High top pressure is creeping in at a much slower rate than in the United States.

Although the proportion of sinter in blast furnace burdens is low overall, the value of sinter is recognized and practically all plants are expanding sintering capacity. Some are pointing toward a charge of 100 per cent self-fluxing sinter. Sintering facilities in a number of plants consist of the horizontal cylindrical rotating kilns, and some of this type are being added. Most of the newer installations, however, are the traveling grate design.

Some unusual sinter coolers were noted. In one plant, a transfer car dumps sinter onto an inclined steel wharf. A baffle, raised somewhat above the wharf, runs the length of the wharf. As sinter is removed onto a conveyor belt, more flows down under the baffle. The installation is similar to the coke wharf universal in coke plants. Another plant uses the sinter cooler as the first part of a conveyor system which carries the sinter to the blast furnace stock bins.

Many European (particularly German) blast furnaces are built with a supporting structural framework rather than the self-supporting design which is universal in the United States. Advantages mentioned for the European design include the freedom of work space because of the elimination of columns, a larger furnace because of thinner lining and—perhaps most important—12 per cent lower cost. Also mentioned were the raw materials and furnace practice, which are said to result in higher temperatures farther up in the stack, presenting cooling problems.

Axial blowers have been applied to a few of the newer installations.

Active mixers are in rather wide use to reduce sulphur and silicon in the iron.

STEELMAKING

As in the case of blast furnaces, open hearth furnaces in the older shops are of small capacity—even down to 25 or 30 tons. The new shops, however, have furnaces of 220 to 290 tons and produce at rates of 30 to 40 tons per furnace hour. There is hesitancy in going to still larger furnaces except for the tilting type.

Oil seems to be the principal fuel, atomized in several cases by compressed air. Compressed blast furnace gas is used to atomize oil in at least one German plant. Considerable attention seems to be given to the design of oil burners.

Several shops in Germany use steam to cool open hearth doors and frames (also continuous heating furnace skid pipes), which is then returned to the steam system.

In some German shops, fans push air through ductwork which directs the air onto the furnace roofs. This is said to keep dust from settling on the roof and to provide a beneficial cooling effect.

Basic roofs and ends are widely used. One plant reports basic roof life of 900 heats on 155-ton furnaces and up to 2500 heats on smaller furnaces. Another plant reports 17 weeks (about 300 heats) on 255-ton furnaces. Still another reports a life of 60 weeks (about 750 heats) with patching on 400-ton tilting furnaces.

Some furnaces, originally of five-door design, are

operating with the second and fourth doors bricked up. This seems to be an economy move, permissible because of a low proportion of scrap in the charge.

Numerous shops use overhead turn-around chargers which move scrap boxes to the furnaces from a ledge between the scrap yard and the charging floor. Only in the new shops, with large furnaces (and probably higher scrap charges) are the floor chargers and tracks for scrap box trains found. Space considerations no doubt contribute to this situation.

The use of oxygen in the open hearths has not progressed to the extent it has in America. In some cases, a little oxygen is used in combustion. Some producers have begun to try oxygen lances for decarbonization.

In general, the larger open hearth furnaces seem to be well instrumented, with wide application of automatic controls.

The basic bessemer process seems to be the backbone of the European steel industry, and since it is so widely used, it has been developed somewhat farther than was the acid bessemer in the United States. Many of the vessels in the older plants are of the order of 12 tons, but the newer installations use vessels of 55 to 65 tons. The new plants are designed for efficient operation. Many have automatic systems for making additions to the converters.

Enriched blast to the extent of 26 to 32 per cent is quite common in the converter shops. In some cases, partial blows of enriched air and of oxygen and steam are alternated. One plant visited used only oxygen and steam, bottom blown. No blower is installed here. Several plants are experimenting with top-blown oxygen in a conventional converter with the bottom sealed up.

But the rush to top blowing with oxygen is on. Favored right now is the LD process or, to take care of the high-phosphorus iron, its modifications using powdered lime, the OLP or LD-AC processes. Many of the plants visited are building or planning such facilities. One plant is already replacing its two 60-ton oxygen converters with three 100-ton units.

The Kaldo and rotor processes are just getting started. Kaldo was developed in Sweden and the first installation outside of that country has recently begun operation at SOLLAC in France. At present an installation is planned for England and two more for Sweden. Rotor installations exist at Oberhausen, where the process was developed, and Peine, Germany, and in South Africa.

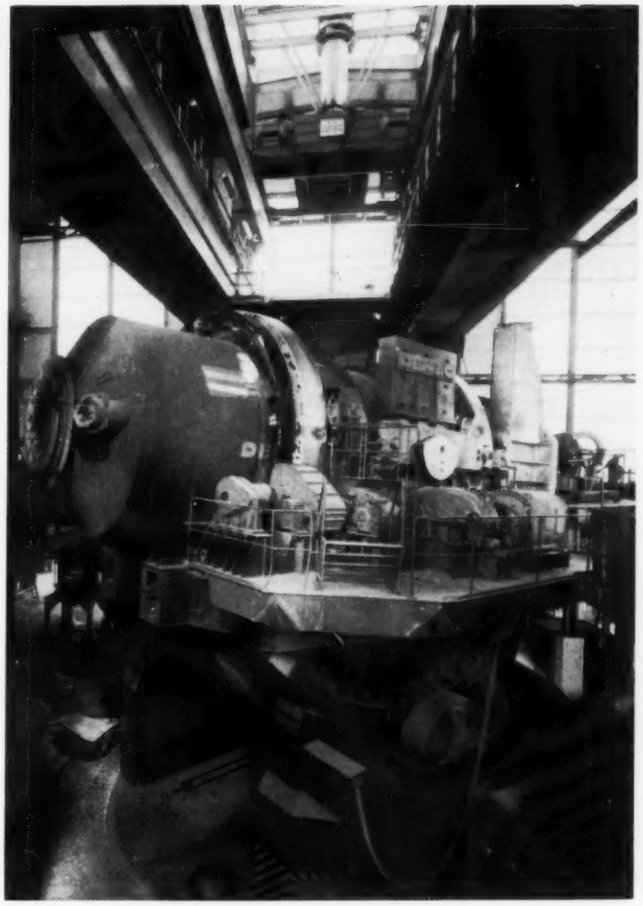
In both of these processes, some of the CO emanating from the bath is burned within the vessel. Consequently they claim a higher percentage of scrap can be charged.

Both of these processes must prove that the added complication of rotating the vessel and the resultant lining wear are justified by the flexibility of the process, steel quality, yield, etc.

Continuous casting is receiving some consideration, but applications lag. Some steel men think it is definitely coming, while others are dubious. Some expressions indicate its future lies in slab casting and one such pilot installation is going into a production plant.

Quite a few steelmaking shops have small arc furnaces from which molten ferro-manganese is drawn for ladle additions. This is said to increase manganese efficiency.

Degassing or vacuum casting of some sort is generally deemed a "must" for certain products, and installations are gradually creeping in.



This rotor steelmaking unit is rotated on its own axis by the drive on the platform, and tilted longitudinally on the rocker beneath the platform. The entire unit revolves on its perpendicular axis on a turntable base.

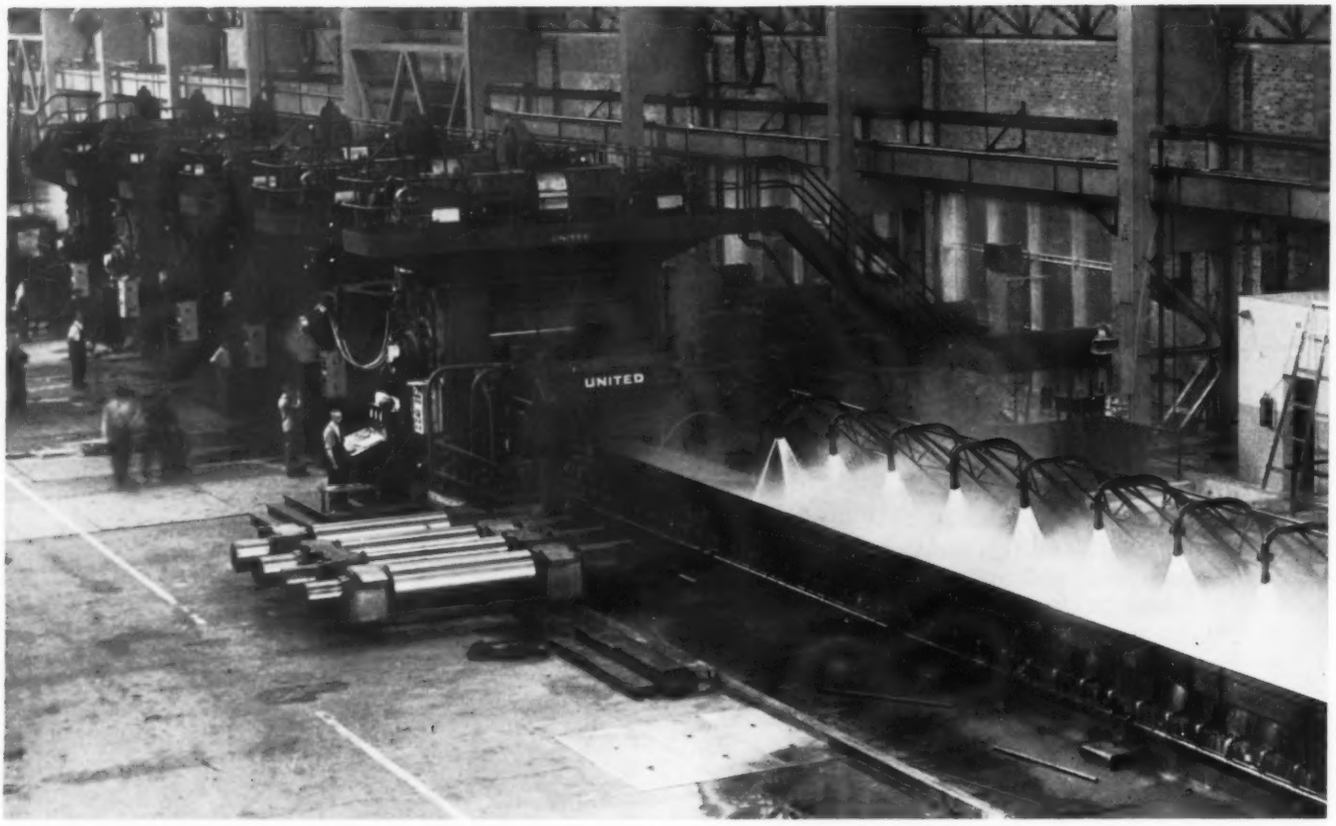
ROLLING

The new rolling mills that have been installed in Europe and Britain are fully the equals of modern American installations, and in some cases have features not common to ours. Many are designed with greater flexibility so as to take care of small orders over a wide range of products. Efforts are made to reduce roll changing time, even to the use of push-button controlled cars that carry two roll stands and move at right angles to the mill line, so that a mill stand can be changed in minutes. Parallel finishing trains permit steel to be switched from one to the other for a change in product.

The old mills—and many are very old—leave much to be desired as far as operating economy is concerned.

Watching mills operate, one gets the impression that they are not pushed as hard as the American mills are. Also, there seem to be more men in the crews.

Automatic control of blooming mills and other large units is entering the picture, but there is little enthusiasm for the complete punch-card systems being installed in the United States. Rather, they prefer simpler systems with greater flexibility. One company has a system developed in the plant. The British Iron and Steel Research Association has developed a system said to be effective and inexpensive.



The 80-in. hot strip mill at Steel Company of Wales' Abbey Works produces hot rolled strip in coils weighing up to 30,000 lb. The mill has been speeded up to a maximum delivery speed of 2200 fpm.

Operating pulpits in a number of mills are cantilevered out over the mill table, and in some cases arranged to swing aside if product flow idles them.

Three German mill machinery designers were visited: Schloeman A. G. at Dusseldorf, Waldrich A. G. at Siegen, and Demag A. G. at Duisburg. Schloeman has no manufacturing facilities itself, but has their designs made on the outside. Waldrich and Demag have good shop facilities of their own. Products seem well designed, sturdy and nicely finished. Great use is made of scale models, both for design purposes and education of future operators.

They see a trend toward universal type slabbing mills, and toward the use of horizontal and vertical roll stands instead of twist guides. It was stated that, because European tolerances on wire are closer than American tolerances, rod mills are comparatively more expensive.

The manufacturers conduct elaborate apprentice systems, usually of three years, during which the apprentice is brought from $15 a month to $25 a month. Good machinists are paid from 63 to 75 cents an hour.

One manufacturer plaintively intimated that European steel men think whatever they see in the United States is just about right.

MISCELLANEOUS

Almost every steel plant visited included a slag plant, a cement plant, a fertilizer plant and a foundry of greater or lesser importance. In general, they seem to be important adjuncts to company economy. It has been humorously said that the French steel industry is a subsidiary of the fertilizer industry.

Plant layouts vary from excellent to pretty bad. Many present-day plants grew by combining a number of small neighboring plants, then adding facilities between them. The results are hit-or-miss arrangements, often congested, with little continuity of product flow and little chance for really economical operation.

On the other hand, the "green-field" plants and those that have been completely rebuilt (sometimes because of war damage and dismantling) may boast of good, efficient layouts.

Housekeeping varies widely from plant to plant, with the newer plants naturally looking better than old ones. A few of the old plants, however, show effort in this direction—and some new ones can stand a little more effort.

In some cases an American might question the location of plants but this is often regulated by government decree. Where Americans might move a plant, or build one in the most economical location, and expect workers to move or commute to it, abroad we might see the plant or part of an over-all operation located where the workers have spent their entire lives, even though it might mean a loss in operating efficiency.

Because fuels are costly, fuel and energy requirements receive much attention. Economies are practiced which could not be justified in the United States. The use of mixed coke oven and blast furnace gases of about 200 Btu per cu ft is rather extensive. A lot of coke gas is sold for outside domestic use. In the Thionville (France) area considerable blast furnace gas is piped to a central public power plant.

Between 25 and 30 gas turbine units are installed or under construction in European plants. Some of these

are blower units, some are generating units and some, to fit into plant energy balances, are combination blowers and generators. This trend started ten years ago.

Almost all of the European steel industry benefits from water transportation. The Rhine River and its tributaries carry heavy barge traffic, aiding both Germany and France. The Lorraine area will soon be further helped by the canalization of the Moselle River, which will give large barges access to the plants around Thionville. Plants in England and Wales have, in many cases, direct tide-water facilities.

Many European plants are more or less in the real estate business. For years "company houses" were an accepted part of the steel industry. A recent trend, however, is to sell lots to employees and lend money at low interest rates for house construction. One company says it will build no more company-owned housing because it believes that ownership creates better mental attitudes than paternalism.

ECONOMICS

Productivity, or man-hours per ton, is always difficult to determine and more difficult to compare. However, calculations based on the number of men employed, typical working hours and ingot production show figures for integrated plants ranging from 11 to 20 man-hours per net ton of ingots, with a great many plants showing around 15. This is not too much higher than the figure in the United States—certainly not more than twice our best plants. In many cases, management knows that the work force could be reduced but does not move in that direction for sociological reasons. They believe it better to keep them working than to put them on a dole.

Average wages were stated to be about 90 cents per hour in England, 84 cents per hour in Holland, 89 cents in Belgium, 70 cents in France, and 85 cents in Germany. These figures, which do not check exactly with some published figures, are based on off-hand estimates. Wages are complicated further by the various allowances for social benefits and additions depending on the number of children in the family. Incentive pay does not seem to be widely used, but one plant visited has a tonnage bonus for each department and a man-hour bonus for the entire plant. In any case, the rates run about one-fourth or less of the average rate in the United States—and the difference in man-hours per ton do not come close to offsetting this.

To this, another consideration might be added. A new blast furnace with all auxiliaries can be built in Germany for $18,000,000, a rod mill for $14,000,000, a plate mill for $3,900,000. In the United States, a complete blast furnace will cost $50,000,000 and similar differentials exist for other facilities.

European working hours differ from those in the American steel industry. Although the eight-hour day is prevalent, shifts may change at 6 A.M., 2 P.M. and 10 P.M., or 5, 1 and 9. In some cases, rolling mills are shut down one-half hour for lunch, when some maintenance jobs may be performed. Mills are frequently operated one or two turns per day, rather than three turns for fewer days. The schedule for supervisors is often 8 A.M. to noon and 2 to 6 P.M. The two-hour lunch period is usually devoted to a heavy meal and perhaps a brief siesta. Work weeks range 40 to 48 hr.

A shortage of engineers was indicated almost everywhere. Starting salaries for newly graduated engineers range $200 to $225 per month. Steel companies in England and Germany trade young engineers back and forth for a year or more to broaden their experience.

Although the labor situation abroad seems much more peaceful than that in the United States, some conditions exist that would make American operators shudder. In Germany, half of a company's board of directors must come from the union. On top of that, the company's director of industrial relations is elected by the union. Nevertheless, German operators say it is not as bad as it sounds.

England has had no general steel strike for 26 years.

In Holland a man may not be discharged nor may he quit without government approval.

It is hazardous to venture into cost information but some selling prices gleaned at random along the way may be interesting:

	per net ton	
	Foreign	U.S.A.
Steam coal	7.00– 7.50	
Coking coal	13.50–16.00	
Coke	18.75–22.00	14.00– 16.00
Scrap	35.00–40.00	26.00– 43.00
Iron ore, 32 per cent Fe	3.37	
Iron ore, 51½ per cent Fe	9.00–14.60	11.50– 12.00
Iron concentrate	16.00	15.00
Pig iron, high phosphorus	37.00–50.00	
Pig iron, low phosphorus	56.00–80.00	62.00– 75.00
Ingots, basic bessemer	62.00–76.00	
Ingots, open hearth	68.00–79.00	76.00– 81.00
Blooms, basic bessemer—France	62.00	
Blooms, open hearth—France	72.00	80.00– 90.00
Cold rolled sheets		
France	102.40	126.00–148.00
Germany	126.50	
Tinplate		
France	214.00	209.00–221.00
Germany	233.00	

Comparisons are difficult to make but U.S.A. prices entered in the foregoing data show we have reason for concern.

German ore prices range 0.8 to 1.3 pfennigs per kilogram of Fe, which converts to $17.50 to $28.30 per net ton of pure Fe.

In England, iron ore for the whole industry is purchased by a central board. A schedule of remissions and levies (complicated to the outsider) may raise or lower costs, depending on the proportions of iron and scrap used in making steel.

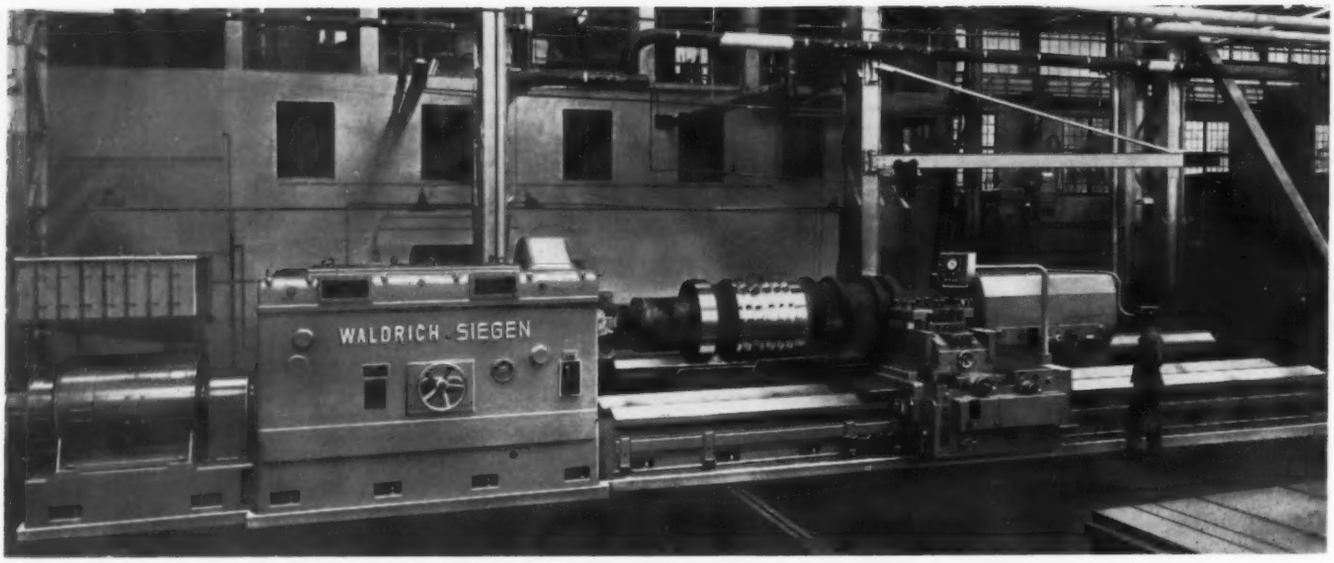
Some conversion costs from one German plant may also be of interest:

	Per net ton of ingots
Open hearth	$15.25–16.25
Basic bessemer	$7.40
Oxygen converter (estimated)	$11.40

In general, German ingot costs are higher than other European countries. French costs are lower and, because of currency manipulation, enjoy an advantage on the international market.

SAFETY

Safety records noted at several plants compared very poorly with American records. Two plants showed



Typical of German machines is this heavy duty roll lathe. Some of these have been installed in the United States.

accident frequency records, according to our calculations, of 12 and 19.5 accidents per million man-hours worked, and these are reputed to be among the best in their respective countries. Another plant checked out at 39 accidents per million man-hours. The frequency record in the United States is 3.51.

Such comparisons might be expected from the spotty use or complete absence of hard hats, safety shoes, goggles, asbestos clothing, etc. Needless to say, the congestion and antiquated methods and equipment prevailing in some of the old plants present many hazards. But basically, the safety idea has yet to be put in the minds of the workers.

RESEARCH AND ENGINEERING GROUPS

In the United States there is very little joint research carried on for the iron and steel industry. Most of the work is done by individual companies for their own purposes. Abroad, however, almost every country has its research center or agency, supported by the whole industry and perhaps by the government, working on common problems of the industry. There are also several iron and steel engineering societies similar to our own Association of Iron and Steel Engineers. A number of these establishments were visited.

The British Iron and Steel Research Association (BISRA), with an annual budget of more than $2,000,000, conducts widespread activities in ironmaking, steelmaking, mechanical working, plant engineering and energy, metallurgy, chemistry and physics. Funds come principally from the British Iron and Steel Federation and the British government, with some coming from direct contributors, research contracts and royalties.

Laboratories are located in London, Sheffield, Normandy and Swansea, and a lot of field work is carried on in various steel plants. Research work currently includes pilot work on processes taking place in the blast furnace, self-fluxing sinter, automatic control of arc furnaces from roof temperature, oxygen in steelmaking, continuous casting, automation of forging presses, vacuum treatment of steel, automatic processing of works data, application of electronic computors, automatic inspection and deseaming of billets, corrosion, etc. A complete list of their work would fill a small volume. Most of the work is applied research and results in many interesting and worthwhile developments.

The French research group, Institut de Recherches de la Siderurgia (IRSID) was established in 1944 by the Iron and Steel Organization Committee. In 1947 construction began on fine research laboratories at Saint-Germain-en-Laye, near Paris. In 1955, a pilot plant was begun at Maizieres-les-Metz. Fundamental research is confined principally to the St-Germain laboratories where 423 people work on metallography, physics, physical and analytical chemistry, etc. The pilot plant, employing 110, is designed for applied or industrial research on ores, blast furnaces and steelmaking. Facilities here are on a scale to permit development work with tonnages large enough to allow full scale methods to be extrapolated from the results.

IRSID developed the OLP steelmaking process, using powdered lime in the oxygen converter, making the process suitable for high phosphorus iron.

Another research group is the Centre National of Recherches Metallurgiques (CNRM), located in Liege, Belgium. Good laboratory facilities are available here and a lot of the work is carried on in the country's steel plants. An important development of this organization is the LD-AC steelmaking process, using powdered lime in the oxygen converter, similar to the OLP process of IRSID.

In Germany, the Max-Planck-Institute for Iron Research is conducted by the Verein Deutscher Eisenhuttenleute. Founded in 1917, the Institute does research in the iron and steel field for the general service of the industry. About 200 persons are employed in the laboratories.

The Verein itself is the German engineering society of the steel industry. It was founded in 1860, has approximately 9400 members and publishes a journal, some books and the archives of the Institute. Its staff num-

bers 160. The total annual budget includes about $850,000 for the society, $475,000 for the research institute and $240,000 spent in college and student activities. Funds come from individual dues, publication advertising and sponsor company memberships.

The Iron and Steel Institute in London does no research work itself but carries on typical engineering society activities. It was founded in 1869 and has a staff of 60 persons. All of their funds come from the dues of its 5000 individual members and from publication advertising.

PLANT DATA

The following pages give some information about the various steel companies visited. In some cases, they present more detailed facts from which previous generalizations were drawn. Because of the way the material was gathered, it is not uniform from plant to plant. It does, however, indicate the expansions that have been made and some of the future planning.

ENGLAND AND WALES

An outstanding plant in the British Isles is the *Steel Company of Wales, Ltd.* This plant was described in some detail in the *Iron And Steel Engineer*, November, 1953 (AISE Yearbook 1953, page 741). Subsequent expansions have brought this company to the following capacities:

	Net Tons per year
Coke (314 ovens)	1,730,000
Iron (5 blast furnaces)	2,320,000
Steel ingots	3,500,000

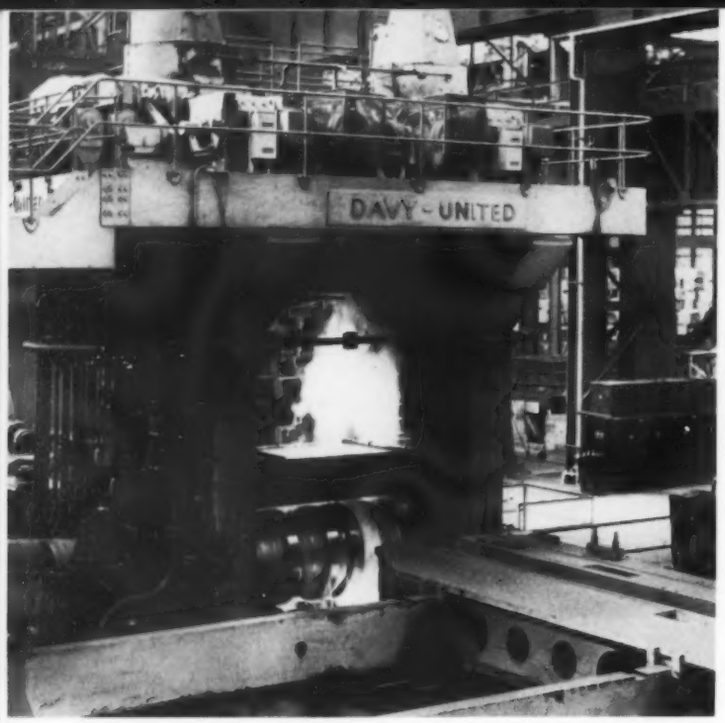
Coking coal with considerable variation in quality, comes principally from mines near the plant. Foreign ores, which supply about 75 per cent of the requirements, arrive by water from many sources and consequently vary in quality. About 20,000 tons of home ore are also used per week. Five sintering lines give a high proportion of sinter in the charge, which runs 46 to 49 per cent Fe. Burdens of 100 per cent self-fluxing sinter are in the plans.

The five blast furnaces range from 21 ft-6 in. to 31-ft hearth diameter. They have refractory brick hearth pads, with carbon side walls, usually up to the tuyere belt. High top pressure is planned for two furnaces. The largest furnace has made a daily record of about 2350 net tons. This unit has 24 tuyeres and is equipped with axial blowers and automatic stove changing facilities.

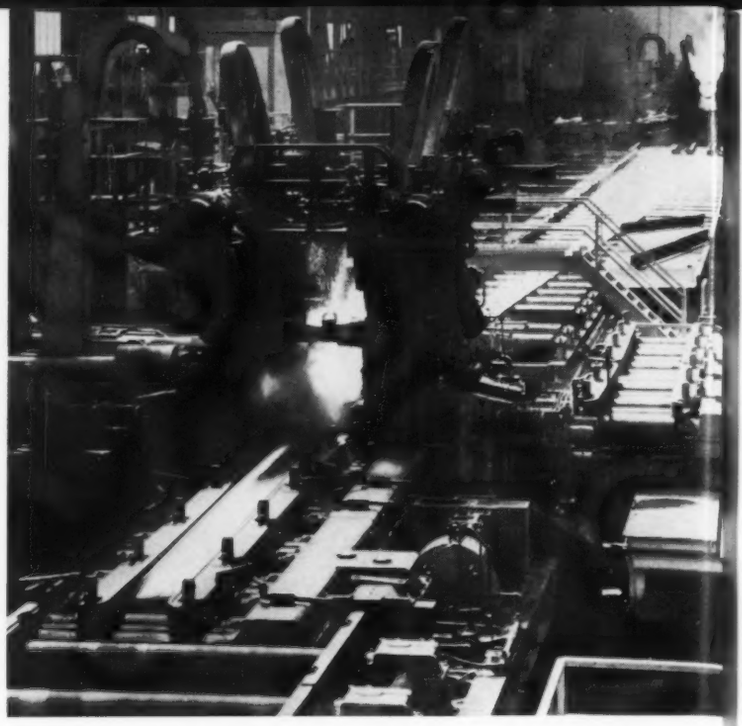
The new section of the plant, Abbey Works, has an open hearth shop of eight 225-ton furnaces and four 255-ton furnaces, all oil-fired, in a typical American layout. Another melt shop in Abbey Works contains three 50-ton converters, bottom-blown with a mixture of steam and oxygen.

At nearby Margam Works there are six 110-ton open hearths, with six more 110-ton furnaces at Port Talbot Works. Plans call for scrapping the furnaces at Port

This 48-in. tandem cold mill is at Trostre Works, one of Steel Company of Wales' two tinplate plants. It handles coils weighing up to 30,000 lb and delivers strip at speeds up to 4497 fpm.



This 52 x 112-in. blooming mill at Dorman Long's new Lackenby Works rolls square or shaped blooms for subsequent rolling in a beam mill or in a continuous billet mill.



The universal beam and heavy structural mill at Lackenby Works of Dorman Long is of modern design with features to insure accuracy of section and high productivity.

Talbot Works, which is to be converted into a chemical plant.

Ingots are rolled into slabs up to 74 in. wide x 8½ in. thick in a 45 x 115-in. universal slabbing mill, served by 34 large pits. Slabs are conditioned, reheated and further reduced in a typical 80-in. hot strip mill with a delivery speed of 2200 fpm. This unit has a monthly capacity of 240,000 net tons of plate up to ¾ in. thick and coils for tinplate and sheet.

Cold reduction facilities for sheet material are located at Abbey Works and consist of a three-stand and a four-stand tandem mill, with pickling and temper rolling equipment. Tinplate is produced in five-stand tandem mills and the usual modern continuous finishing equipment at the company's Trostre and Velindre Works some 25 miles away.

A continuous casting unit is being installed for the production of 9 x 48-in. slabs at the Abbey Works.

The company's power houses provide a total generating capacity of 43,250 kw. This includes a new 9250-kw topping turbine served by a new 3300-psi 240,000-lb per hr boiler.

The total work force is stated to be 17,500 at 42 hours per week. Putting this against an ingot production of 3,500,000 tons gives 11 man-hours per net ton of ingots.

The modern portions of the Steel Company of Wales, which include the Abbey, Trostre and Velindre Works, are well laid out, well maintained and efficiently operated. They are as good as most modern American plants and better than many.

The *Guest Keen Iron and Steel Company, Ltd.*, operates a steel plant at Cardiff, Wales. Originally built in 1937, the facilities now include four 18-ft blast furnaces, two 115-ton stationary open hearth furnaces, five tilting open hearths of 200 to 300 tons capacity (one used as a mixer), 24 new soaking pits, a 40-in. bloomer, a continuous billet and sheet bar mill, and a Lamberton mill for light sections.

The blast furnaces turn out about 18,000 tons of iron per week. Steel production runs about 830,000 tons per year. Billets and slabs form about 75 per cent of the plant product, with the rest in sections, rails, etc.

The plant has an iron foundry which produces, among other things, ingot molds and bottom plates. They have shipped some ingot molds to the United States.

Adjacent to the steel plant is Guest Keen & Nettlefolds (South Wales) Ltd., a large producer of fasteners of many kinds. Billets from the steel plant are rerolled in a 12-in. bar mill and a 9-in. two-strand rod mill.

Products includes small sections, flats, rounds, reinforcing bar, narrow strip, wire, nails, etc.

Some reinforcing bar is processed in a Tentor plant, wherein it is stretched and twisted. This cold working is said to increase strength by 20 per cent. The machines were developed in Denmark.

Dorman Long (Steel) Ltd. consists of a group of works grouped along the River Tees, near Middlesbrough in northern England. Most of these works were at one time independent companies.

The newest is Lackenby Works, where operations started in 1953. Here are five 400-ton tilting open hearth furnaces, a slag plant, a universal beam mill and a combination merchant bar, rod and strip mill.

The open hearth furnaces operate on 20 to 25 per cent scrap, 75 to 80 per cent iron. They are served by overhead turn-around chargers and two 670-ton active mixers in which sulphur and silicon are reduced. Steel is tapped into 100-ton ladles which are put in a teeming car which straddles the mold drag. These furnaces have produced more than 800,000 net tons of ingots per year.

Ingots are heated in 12 recuperative pits and roughed down in a 52 x 112-in. bloomer. Shaped blooms may proceed directly to universal beam stands or, if desired, may first be put through a reheating furnace. Rectangular blooms from the 52-in. may move directly

to a 40 x 96-in. reversing breakdown mill or may first go through the reheating furnace. The breakdown mill can feed either to a continuous 4-stand billet train or to the structural stands which are interchangeable with the universal beam stands.

The beam mill itself was designed to produce 50,000 net tons per month of standard structural sections and H-beams up to 36-in. x 16½ in. It has two reversing universal stands which operate under pre-set pass control.

The combination merchant mill is also a very flexible unit. It produces bars of ½ to 1¼ in. diameter, angles up to 2 in., flats up to 2½ in., strip up to 12 in. wide, and rods (3-strand) down to No. 5. Rolling rates vary from 30 to 70 tons per hr.

Cleveland Works, largest of the group, is actually an integrated unit. Coking capacity for 2,700,000 net tons of coal per year is provided by 282 ovens. There are two groups of blast furnaces, one of three 18 ft 6 in. furnaces, one of two 27 ft 6 in. furnaces. Four continuous sintering machines turn out about 190,000 net tons of sinter per month.

Steel is produced in two open hearth shops, one with seven 120-ton furnaces, the other with five 180-ton furnaces.

Rolling facilities at Cleveland Works include a blooming mill, a rail mill, a small section mill and a medium section mill.

Redcar Works has two 18-ft blast furnaces, an open hearth shop of ten 105-ton furnaces and two plate mills. Sheared plate is produced up to 108 in. wide, universal plate 12 to 45 in. wide and up to 3 in. thick. Combined the two mills produce about 31,000 tons per month.

Acklam Works has four 17-ft blast furnaces, four 280-ton tilting open hearth furnaces and mills which turn out blooms, billets, slabs and sheet bar.

Adjacent to Acklam Works is a sheet mill which turns out about 4800 tons of sheets per month, using a three-high mechanized rougher and two two-high mechanized finishing stands.

Brittannia Works now consists of four section mills which produce about 31,000 net tons per month of structural shapes covering almost the entire British standard range. A wire mill is also located here.

Dorman Long has a total ingot capacity of about 2,600,000 net tons per year. The product is heavy in structurals.

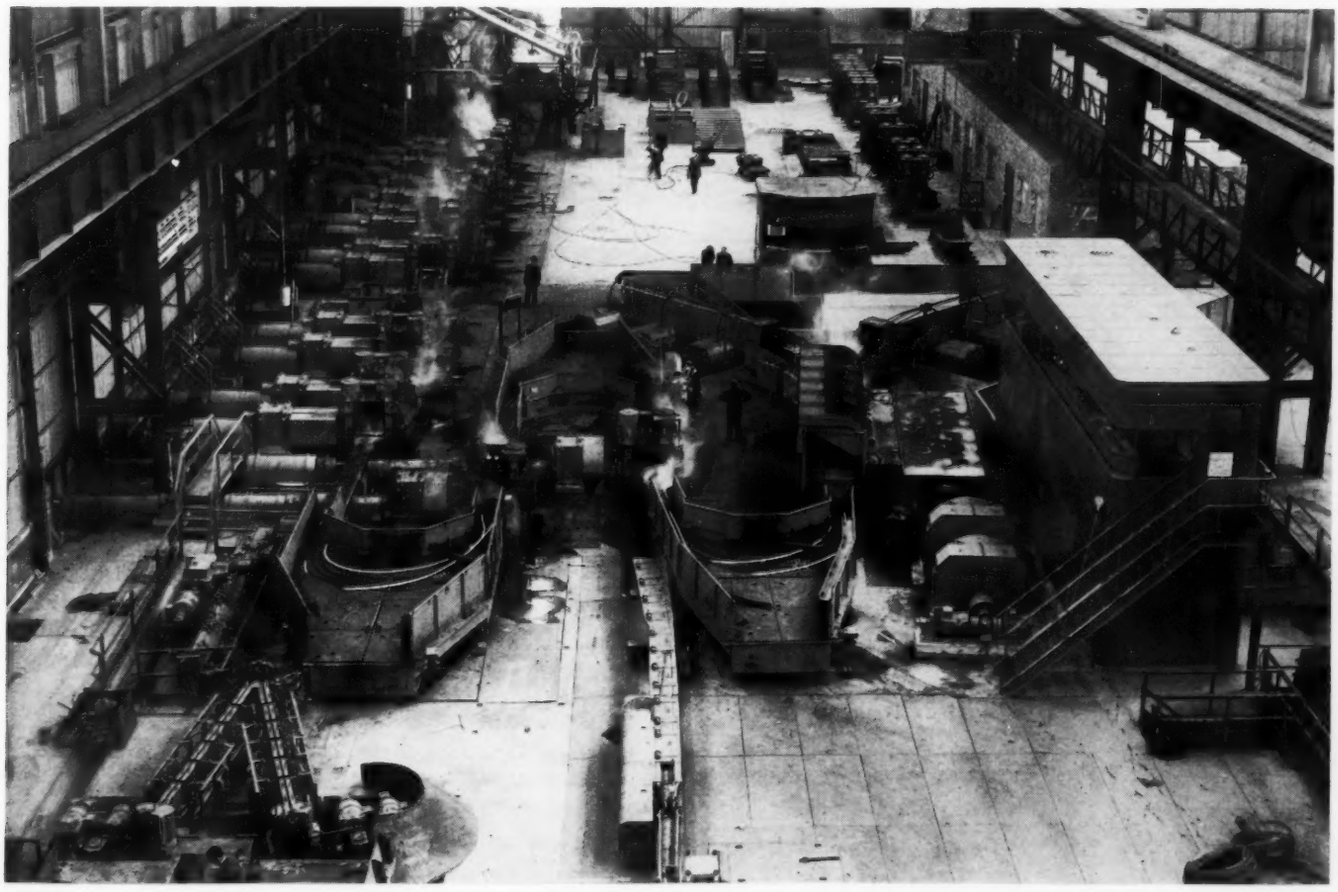
South Durham Iron & Steel Company, Ltd. at West Hartlepool produces plates of various types, slabs, sheets, electric weld pipe, fabricated tanks, etc.

There are 78 coke ovens, two blast furnaces (one new), six 400-ton tilting open hearths, an old blooming mill, a heavy plate mill and a light plate mill.

A new plant is nearing completion, consisting of a sintering plant, two 28 ft 3 in. blast furnaces, an active mixer, five tilting open hearth furnaces and a plate mill consisting of a scalebreaker and two four-high stands. When this plant is fully in operation, the old bloomer and heavy plate mill will be shut down.

Steel is tapped into ladles which are placed on a

The Lackenby merchant, rod and strip mill has a very flexible layout. Strip is delivered through the vibrators forming a Y at the lower left. Bars exit to a cooling bed over the conveyor at lower center. Rod proceeds to coilers below the floor at center.



carriage running at right angles to the melt shop into an adjacent teeming bay. The ingots are stripped here and moved to the adjacent pit building.

The interiors of the new mill buildings present an attractive appearance with the structural work painted a pale blue and the roof and wall areas a canary yellow.

The company also operates a welded line pipe plant at Stockton-on-Tees.

HOLLAND

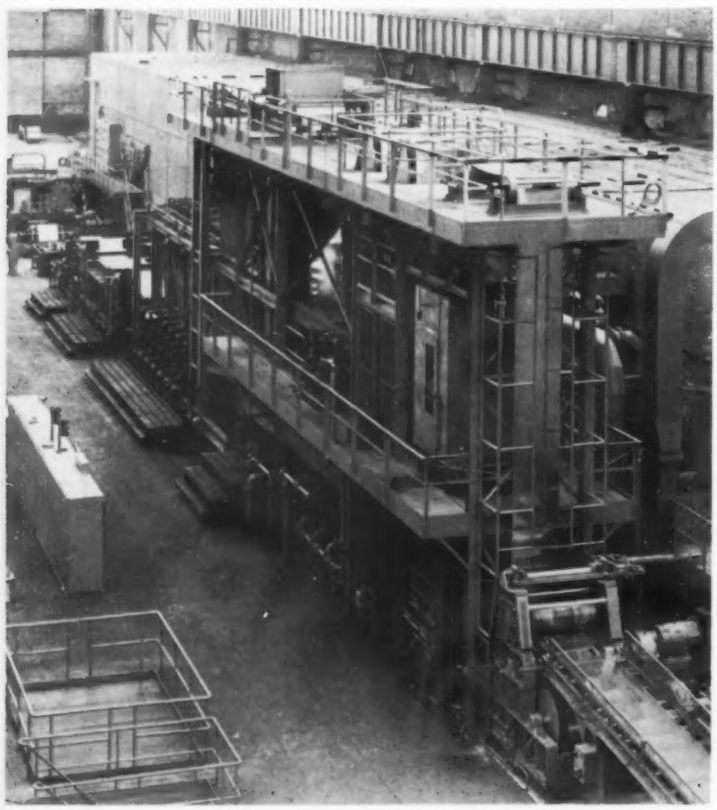
One of the most interesting organizations on the European continent is the *Koninklijke Nederlandsche Hoogovens en Staalfabrieken N.V.* (*Royal Netherlands Blast Furnaces and Steelworks*), and affiliated companies, centered principally around Ijmuiden. It had its inception in 1918, with the decision to build a steel plant, in spite of insufficient coal and no ore in the country.

Production began with one battery of coke ovens and two blast furnaces. By 1930 there was a third blast furnace, a cement plant and a fertilizer plant. In 1936 a cast iron pipe foundry was put into operation. Soon after, it was decided to construct a steel melting shop and a plate mill. A nearby sheet mill was taken over.

After World War II, extensive work was necessary to repair damage from military operations and from dismantling by the Germans. Then came expansion in iron and steel capacity, a slabbing mill, a hot strip mill, cold mills and tinning facilities. In 1955 and 1956, further extensions included two batteries of coke ovens, a sintering plant, a desiliconization plant and the sixth open hearth furnace.

Another expansion was completed in 1958, covering another battery of coke ovens, the fourth blast furnace, an oxygen steelmaking shop and an electrolytic tinning line.

This electrolytic tinning line at Breedband, N. V., is of American design. A second line of the same type is on order.



Present activities are pointed to bringing iron capacity to 1,870,000 net tons per year and steel capacity to 2,090,000 net tons per year. A second tandem cold mill and a second electrolytic tinning line are being constructed.

Present thinking sees an ingot capacity of about 3,000,000 tons per year with relatively small expenditure. This will, of course, require new finishing mills. An eventual capacity of 5,500,000 net tons or more per year is believed possible.

The plant, which has a good layout and is nicely kept, is served by one harbor with direct connection to the North Sea, and three harbors connected to the North Sea Canal. Thus, most of the raw materials arrive by water transport, which is also available for shipment of products.

About half of the coal used is imported from the United States, with the rest coming from West Germany, Belgium and the south of Holland.

Iron ore comes from Sweden, Africa, Spain, Canada and South America. It is all low in phosphorus, with over 50 per cent iron. After sintering, a furnace burden of 59 per cent iron is available.

There are now seven batteries totaling 184 by-product coke ovens producing about 3300 net tons of coke per day. Some coke gas is used in the production of fertilizer and other chemical products. Most of the gas, however, is sold to municipalities in North Holland.

Of the four blast furnaces now operating, one has a 28-ft hearth and produces up to 1980 net tons per day. Coke consumption averages 1400 lb per net ton of iron. A fifth blast furnace (with high top pressure) is under construction and will be ready in the last half of 1961. Blast furnace gas is used in the stoves, coke ovens, power station, etc., with any excess going to a public utility generating station in the area.

The pipe foundry uses the sand-spun system and can produce 44,000 net tons of pipe of 4 to 12-in. diameter.

Steel is made by the basic open hearth and oxygen converter processes. There are six 220-ton open hearth furnaces, which are gradually being converted to all-basic construction with two oxygen lances through the roof. Furnace charges run 50 per cent hot metal, 50 per cent scrap. All hot metal is desiliconized, using lime and oxygen. Silicon, which ranges 0.6 to 0.8 per cent in the iron, averages 0.3 per cent in the charge metal. Oil is the principal fuel, with any coke oven gas that is available. Some oxygen is used in combustion. Heats are turned out in about seven hours.

In the oxygen steel plant, two 60-ton converters are being replaced by three 100-ton units. Additions to the converters are "dialed" and put into the converters automatically by a system developed by the plant electrical department.

The slabbing mill is a two-high, 43 x 108-in. reversing unit, driven by a 7200-hp motor. It receives ingots of 10 to 16 tons which have been heated in top-fired recuperative pits. It produces slabs up to 56 in. in width, 5 to 11 in. thick, at a rate of about 265 net tons per hr. An edge scarfer is installed in the runout table.

Plate is rolled from reheated slabs in a mill consisting of a two-high rougher and a four-high finisher, both

No. 4 blast furnace at the Royal Netherlands Blast Furnaces and Steelworks, Ltd., is a 28-ft unit with electrostatic gas cleaning. The fifth furnace, now under construction, will be of similar design but with high top pressure.

reversing. This mill turns out plate up to 112 in. wide, up to 1½ in. thick, at rates averaging about 1350 tons per day. Most of this product goes to the Netherlands shipbuilding industry.

A sister company, Breedband, N.V., provides strip rolling facilities. The 56-in. hot strip mill has three reheating furnaces, a scale-breaker, a reversing rougher and six finishing stands. It has a maximum exit speed of 2300 fpm and produces coils weighing six to seven tons. It has a nominal capacity of 1,500,000 net tons per year.

The existing 4-stand tandem cold mill will soon be joined by the new 5-stand mill, and tinning capacity is being expanded.

In 1959, these plants produced the following approximate tonnages:

	Net tons
Pig iron	1,257,000
Open hearth steel	1,030,000
Oxygen-blown steel	484,000
Cast iron pipe	30,000
Plate	380,000
Hot rolled coils	897,000
Hot rolled sheets	70,000
Cold reduced material	488,000
Hot-dipped tinplate	82,500
Electrolytic tinplate	66,500
Cement	668,000
Pure nitrogen in nitrogenous fertilizers	108,500

Approximately 40 per cent of the total production is exported.

The total force of the plants is 13,280 including salaried personnel, construction forces, and cement and fertilizer plant crews. The work week is 45 hr. For what it is worth, a quick calculation shows 20.6 man-hours per ton of ingots produced. This figure is of course high because it includes men not related to iron and steel production.

In 1959, the total payroll cost for these plants was 96,400,000 guilders (about $26,000,000), including base wages and salaries, and social and fringe benefits. Another calculation shows the over-all wage cost to be about 3.1 guilders (about 84¢) per man-hour. A wage increase is expected in the near future. An interesting sidelight is the fact that a man cannot leave his job or be fired without government approval.

Perhaps most interesting of all is the fact these affiliated companies have paid dividends of 16 to 20 per cent in each of the past four years.

BELGIUM

Societe Anonyme Metallurgique d'Esperance-Longdoz is a relatively small producer located on both sides of the Meuse River at Jemeppe and Seraing, near Liege, Belgium. It has a history going back 125 years. The plant is hemmed in between the river and hills and has various levels.

The plant depends principally on iron ore from the Minette fields in France, which arrives by rail, and coal from northern Belgium, arriving by river barge.

Coke is produced in 125 by-product ovens with a total capacity of around 570,000 net tons of metallurgical coke per year. Coke is carried across the river by belt conveyor to the stock bins of the blast furnaces, about 7000 ft away.

There are four small blast furnaces of 14-ft hearth diameter, one 20.5-ft furnace and one very new 28.7-ft furnace, providing an annual capacity for about 1,200,000 net tons.

Steel is made in six 22-ton basic bessemer converters which are blown with oxygen and steam or with enriched air. The steel is top-poured into ingots 16½ in. thick, 30 to 52 in. wide and 6600 to 11,000 lb in weight. Before teeming, two waster sheets are dropped on edge into the mold, forming a rough cylinder at the bottom, to reduce spashes on the mold walls. The hot ingots are moved by rail across the river to the hot mill.

Ingots are heated in 12 recuperative soaking pits, fired with mixed blast furnace and coke oven gas of 180 to 200 Btu per cu ft. Heating time ranges from 3 hr for hot ingots to 10 hr for cold ingots.

The only hot rolling mill is a 54-in. semi-continuous strip mill, which rolls strip directly from the ingot. The two-high reversing rougher is a 35 x 51-in. unit with a maximum lift of 18 in. It reduces ingots down to a thickness of about ¾ in. This breakdown then goes directly through a five-stand finishing train. The first two stands are 20 in. and 42 x 54 in., the last three 16½ in. and 46¾ x 54 in.

This mill will roll about 880,000 net tons per year, including 100,000 tons of purchased ingots.

Finishing equipment includes continuous pickling, a three-stand 56-in. tandem cold mill, a sendzimir cold mill, annealing furnaces, temper mills, etc. About 20 per cent of the product goes to the automotive industry, 70 per cent to the appliance field. Hot rolled coils represent 10 per cent.

The plant employs about 6000 persons.

The company is planning for new soaking pits, a slabbing mill with scarfer, and probably reheating furnaces for the strip mill.

Societe Anonyme Cockerill-Ougree, headquartered at Seraing, Belgium, was established in 1955 through the merger of three companies. The main plant stems from a number of small plants started 100 years ago, which gradually combined. Hence, the layout is irregular and congested.

Coke is supplied by 317 by-product ovens. There are 12 small blast furnaces in two separate locations which operate on Minette ores from France and some local ore, all high in phosphorus. Hence, steelmaking is principally by the basic bessemer process in two separate shops. One bessemer shop is new and presents a good example of the degree to which this process has been developed in Europe. This shop has five 66-ton converters with good controls and instruments. Additions to the converters are made automatically. Oxygen blowing is to be tried on one converter.

There are ten basic open hearth furnaces (25 to 65 tons each), two or three furnaces being located at four or five different sites.

A considerable portion of the tonnage goes through a 46-in. blooming-slabbing mill, a reversing 138-in., four-high plate mill and a six-stand 68-in. continuous strip finishing train. The bloomer operates under an automatic control system developed within the company.

There are also other mills for plate, rail, structurals, merchant bar, sheet bar, rod and narrow strip. Several mechanized sheet mills are still in operation.

Ingot capacity is about 1,800,000 net tons, with 2,200,000 tons the goal of present plans. Currently, a huge slag dump is being removed to prepare a site for new blooming, billet and rod mills.

A low blast furnace is used for test purposes. It is said that full scale operations can be accurately predicted from tests run on this unit.

The company also operates two other small steel producing plants and a cold strip finishing plant. The latter has two reversing cold mills, annealing and temper rolling facilities and an electrolytic tinning line.

FRANCE

The principal plant of the *Union Siderurgique du Nord de la France* (*USINOR*) is located at Denain in northern France.

About 60 per cent of the ore comes from the Minette fields, 20 per cent from Sweden and 20 per cent from western France. Coke is purchased from ovens at the nationalized coal mines nearby. The steel plant also buys coke oven gas and sells some blast furnace gas to the coke ovens.

At Denain there are five blast furnaces, three open hearth shops (15 furnaces, 35 to 165 tons), a basic bessemer shop (five 30-ton converters), a 10-ton electric furnace, slabbing, blooming and billet mills, merchant mills and a 66-in. hot strip mill.

At Valenciennes are four blast furnaces, open hearth shop (four 45-ton furnaces) and basic bessemer (five 28-ton converters) shop, blooming and merchant mills, and forge shop.

The Louvroil plant has three blast furnaces, four 28-ton basic bessemer converters, blooming, billet and merchant mills.

An open hearth shop (four 25-ton furnaces) and merchant mills are located at the Haumont plant, and a rod mill at the Anzin plant.

All of these plants are grouped near each other in northern France. In addition, there is a plant at Montataire, near Paris, where hot rolled coils from Denain works are pickled and cold rolled.

Monthly capacity is said to be 198,000 net tons of iron and 250,000 net tons of ingots. About 70 per cent of the product is strip and plate.

USINOR is currently building a new plant at Dunkirk on the North Sea coast, consisting of a blast furnace, an oxygen steel converter shop, slabbing and plate mills. This will be followed by two more blast furnaces, a beam mill and a strip mill. The new location will provide direct water transportation for imported ores and exported products. The company's capacity will thus expand to about 450,000 net tons of ingots per month.

Lorraine-Escaut was formed in 1953 by the merger of three companies dating back to the 1880's. It now has a total capacity of 2,200,000 net tons of ingots per year. Steel production is centered in a plant at Longwy and one at Thionville. In addition, the company has sheet

mills, merchant mills, pipe mills and foundries at Sedan, Laval-Dieu, Brevilly, Maubeuge, Anzin, Nosy-le-Sec and Bessages. It also is a participant in the SOLLAC project.

The Longwy plant is in two divisions: deMont St. Martin and Senelle, both cramped between hills and river.

Two blast furnaces at St. Martin produce 1000 net tons of iron a day. At Senelle, six blast furnaces turn out 2500 net tons per day and a new 23-ft furnace is expected to make 770 tons a day. The furnaces operate on the local Minette ore which is brought from the mines to a crushing station by an aerial cable conveyor carrying buckets. As mined, the ore runs about 30 per cent Fe, which is brought up to 42 per cent by beneficiation. A new 3000-ton-per-day sintering plant has just been added to an old 1200-ton unit.

Each division has a basic bessemer shop and a small open hearth shop which provide a total capacity of 132,000 net tons of ingots per month.

Senelle division has a blooming, billet and merchant mills. St. Martin division now has two old bloomers, one of which is to be modernized, the other dismantled.

A modern plate mill, similar to that at U. S. Steel's Homestead Works has been installed at St. Martin Division. It is served by eight soaking pits and a continuous reheating furnace. A second reheating furnace is in construction. The mill consists of a two-high spreading stand and a four-high finishing stand, both reversing. Monthly production runs about 37,000 net tons.

The plant also has secondary mills for the production of rails, structural shapes, piling, etc.

An old rod mill at St. Martin is to be replaced, and a new oxygen steel converter plant is to be constructed. By 1965, Longwy plant is expected to produce 190,000 net tons of ingots per month.

The Thionville plant, which was not visited, has a coke plant, sinter plant, blast furnaces, bessemer converters, open hearth and electric furnaces, and mills for rolling blooms, billets, merchant bar and bands.

Lorraine-Escaut produces about 500,000 net tons of tubular products per year, in seamless up to 16-in. outside diameter and in welded up to 60-in. outside diameter. A new welded pipe line was recently completed at the Sedan works. It is designed for an annual capacity of 165,000 to 220,000 net tons of line pipe, 16 to 40 in. outside diameter (in 2-in. increments), ¼ to ½ in. wall thickness and 40-ft lengths. The U-press is a 500-ton unit, the closing press 7000 tons. Welding is by the twin-electrode submerged-arc process. Internal hydraulic pressure expands the welded pipe about 1.6 per cent.

The Union Siderurgique Lorraine (*SIDELOR*) was formed in 1950 by the merger of five small companies grouped to the north of Metz. The company holds extensive mine properties in the general area.

Exclusive of an interest in SOLLAC, SIDELOR has four producing plants. At Aboue there are three small blast furnaces of 220,000 tons of iron per year total capacity. At Homecourt are a coke plant, five small blast furnaces, a basic bessemer shop, an open hearth shop and blooming, billet, plate and merchant mills. Ingot capacity here is 660,000 net tons per year.

Another 660,000-ton plant is located at Micheville,

Finishing stands of the 66-in. hot strip mill at Union Siderurgique du Nord de la France (USINOR).

consisting of a coke plant, five blast furnaces, basic bessemer shop, open hearth shop, an electric furnace and blooming, billet, structural and merchant mills.

The largest plant is at Rombas, with 1,100,000 net tons of ingots per year. Here are eight blast furnaces, basic bessemer and open hearth shops, two blooming mills, two billet mills, two large structural mills, five merchant and small structural mills and two rod mills.

The Rombas plant turns out about 11,000 tons per month of open hearth steel and 80,000 tons of basic bessemer steel, as well as 1600 tons of iron castings and 2200 tons of steel castings. It sends about 11,000 tons of iron per month to the SOLLAC plant. It also ships some ingots, blooms and slabs to other plants and in turn, receives some ingots. It makes about 110 tons a day of hot dip tinplate, using black plate from SOLLAC.

By 1963 it is planned to increase sintering capacity to 4500 tons per day, iron capacity to 135,000 or more tons per month, and ingot capacity to 190,000 tons per month. This project may include oxygen steelmaking equipment. Electrification for some of the old mills is also in the works.

An interesting piece of equipment was being installed at the Rombas plant, consisting of a 72,000-cfm blower, a 14,000-kw generator and a gas turbine. This unit can operate as a turbine-driven blower, a turbogenerator or an electrically driven blower. Its purpose is to improve the energy balance of the plant.

De Wendel & Cie S. A. is a major French producer with four operating plants:

Hyange Works—Ten blast furnaces, six basic bessemer converters, six open hearth furnaces, rolling mills for rail, structural sections, heavy and medium plate, universal plate and sheet.

Moyeuvre Works—Six blast furnaces, 66 coke ovens, five converters and bloom, billet, merchant and rod mills.

Joeuf Works—Six blast furnaces, six converters, heavy and medium mills, rod mill.

Messempre Works—Sheet mill.

Only the Joeuf rod mill was visited. This is an American-built unit, put into operation in 1955, with a modern, efficient layout. A continuous side-charge, side-discharge reheating furnace, approximately 32 x 60 ft, heats billets 2.68 in. or 3.15 in. square.

The roughing train consists of seven 16-in. stands and four 14-in. stands. There are eight 12-in. intermediate stands with the last four split into two separate parallel rolling lines, each leading to a finishing train of six $10\frac{1}{2}$ in. stands. Product leaving the No. 23 stands goes to two groups (four each) of reels. Larger product finished out of the No. 17 stands goes to two groups of two reels each.

The mill operates with four strands, with repeaters between No. 13 and No. 14 stands and between No. 15 and Nos. 16 and 16-a.

The mill operates with a 32-man crew per turn and a total of 65 men per turn.

The de Wendel organization is expanding to a future annual capacity of 3,300,000 net tons of ingots. It is also a participant in SOLLAC. A large blast furnace is currently under construction.

La Societe Lorraine de Laminage Continu (*SOLLAC*) was founded in 1948 by seven other French steel companies to build a modern wide strip mill, a project somewhat beyond the capacity of any one of the companies. Construction was begun at Seremange and Ebange in 1950 and the hot strip mill and a tandem cold mill were started up during the winter of 1952–53. The blooming mill and open hearth began operations in 1953, and the basic bessemer shop, another tandem cold mill, and an electrolytic tinning line in 1954. The plant is well laid out, well kept and well operated.

At present, the plant makes steel in four open hearth furnaces (two of 155 tons, two of 220 tons), four 60-ton basic bessemer converters and a 110-ton Kaldo oxygen unit. Monthly production runs about 50,000 net tons from the open hearths, 94,000 from basic bessemer and 38,000 from the Kaldo unit. In addition, some hot ingots and cold slabs are shipped in from various participants in the combine. Since the plant has no blast furnaces, hot metal for steelmaking also comes in from member companies nearby.

The Kaldo unit is a recent addition, the first to go in outside of Sweden. The vessel closely resembles a conventional converter but is so mounted that it also rotates at 2 to 32 rpm. A typical charge is 65 tons of hot metal (1.7 to 2.0 per cent phosphorus) and 45 tons of scrap, plus lime as needed for phosphorus removal The unit is top blown with oxygen as the vessel rotates. There are two vessels but only one operating rig. Hence. one vessel operates while the other is positioned on a relining stand nearby. Vessels are exchanged by a transfer car with hydraulic lift.

The process is making satisfactory steel for deep-drawing sheets. The installation started up on single-turn operation in order to break in the equipment and operating crews. Consequently, good operating data was not available. With hot metal averaging 1.7 per cent phosphorus, 0.04 per cent sulphur, the steel produced averages 0.015 per cent phosphorus and 0.01 per cent sulphur. Yields are said to average about 90 per cent. Heats up to 122 net tons have been made.

Ingots are heated in 27 soaking pits with a holding capacity of 2500 tons. They are rolled into slabs on a high-lift blooming mill.

The 80-in. hot strip mill is of conventional American design, with four reheating furnaces. It has set records of 7900 net tons per day and 193,500 net tons per month. It takes a maximum slab of about 13 tons.

Cold finishing equipment is located in a separate plant in the area. There are two continuous pickling lines (one 80 in., one 66 in.), an 80-in. three-stand tandem cold mill, a 48-in. five-stand tandem mill, an electrolytic cleaning line, annealing furnaces of the portable cover type, one continuous annealing furnace, three skin-pass mills, two electrolytic tinning lines and an electrolytic galvanizing line.

A typical month might show 115,000 tons of strip pickled, 60,000 tons from the five-stand mill, and 55,000 tons from the three-stand mill. Pickled coils to the five-stand will range up to 30,000 lb and to the three-stand mill, 40,000 lb. Some coils are shipped to a small finishing plant at Dilling. Some black plate is sent to combine participants. End products from the Ebange plant might run 50,000 tons per month of cold-rolled sheets, 27,000 tons of tinplate and 3000 tons of galvanized sheets.

Plans here are pointed toward a hot strip production of 275,000 net tons per month. Slab heating capacity is

Oxygen steelmaking is growing rapidly. Two 60-ton converters at Royal Netherlands Blast Furnaces and Steelworks, Ltd., are to be replaced by three 100-ton vessels.

being increased, while finishing facilities are undergoing expansion with the addition of another pickler, another five-stand tandem mill, a two-stand temper mill, an electro-cleaning line and two shearing lines.

The plant also has 120 by-product coke ovens with a total capacity of 2640 tons of coal per day. This is operated as a gas producer, with some of the gas being sold and some used in the plant. The coke is shipped to nearby blast furnaces.

LUXEMBOURG

Acieries Reunies de Burbach-Eich-Dudelange S. A. (*ARBED*) was founded in 1911 through the union of three companies operating in the Grand Duchy of Luxembourg and in the Saar. Since that time, the company has expanded and now includes operations in Belgium and in the Saar. Total capacity is 3,500,000 net tons of ingots per year.

Briefly, the company now operates the following plants:

Belval Works—Ore preparation, six blast furnaces (2700 tons per day), six 35-ton basic bessemer converters (4000 tons per day), a 25-ton electric furnace, two blooming mills, secondary mills for a wide variety of structural shapes, piling, rails, merchant bar, rod, narrow strip and skelp.

Terre Rouge Works—Ore preparation, five blast furnaces (2200 tons per day).

Esch Division—Three blast furnaces (1400 tons per day), five basic bessemer converters (2600 tons per day), a blooming mill and five finishing mills for small structurals, merchant bar and rod.

Dudelange Division—Ore preparation, three blast furnaces (1700 tons per day), four 30-ton converters (1800 tons per day), a 66-in. hot strip mill, cold strip mill and finishing equipment.

Dommeldange Division—Four 13-ton electric arc furnaces, one 3000-lb induction furnace, two rolling mills for special steels, foundry and forge shop.

Burbach Works—Coke plant (3000 tons per day), ore preparation, eight blast furnaces (2750 tons per day), a new converter shop of four 50-ton vessels (3500 tons per day), four 33-ton open hearth furnaces (9300 tons per month), a blooming mill and six finishing mills for large, medium and small structural shapes, merchant bar and large flats.

Hostenbach Works—Rolling mills for light plate and sheet.

Only the Dudelange plant was visited. Here three sintering kilns sinter Minette ores from France and Luxembourg, raising iron content to about 42 per cent. About 38,000 net tons of sinter is made per month which, with 120,000 tons of ore, is used to produce 48,000 net tons of iron. Approximately 47,000 tons of coke per month are purchased, arriving by rail from Belgium, Germany and Holland.

The three blast furnaces normally produce about 45,000 net tons of iron per month. A new 23.7-ft blast furnace is under construction and is expected to give 770 tons of iron per day.

About 47,000 net tons of steel per month is made in four 30-ton basic bessemer converters. Three of these are bottom-blown by air enriched to 30 to 32 per cent oxygen. The fourth vessel is top-blown with oxygen and powdered lime. A new oxygen steel converter is being installed.

Ingots of 3 to 12 tons are heated in four circular and three rectangular recuperative pits fired with blast furnace gas, and then proceed to a 43 x 108-in. slabbing mill driven by two 3500-hp motors.

The slab, about 4 in. thick, proceeds to a 42 x 66-in. reversing universal mill driven by a 5000-hp motor where it is reduced to about $\frac{5}{8}$ in. thickness. The strip is then finished in a reversing 66-in. hot Steckel mill. A special alloy used for the reels in the coil furnaces now last 18 months. An interesting item is the application of

The Kaldo vessel is charged with scrap and molten iron and blown through the top by an oxygen lance. Burnt lime and ore additions are charged from overhead bins. This unit at SOLLAC is rated at 110 tons.

a photo-cell to actuate a crop-shear. This was developed in the plant. The mill can roll at a rate of 78 net tons per hour.

Strip is finished in a continuous pickler, two four-high reversing cold mills, annealing furnace, temper mill, a continuous galvanizing line, etc.

A typical month's shipments might show 8800-net tons of plate, 24,000 tons of cold rolled sheet and coils, and 1000 tons of galvanized sheet.

WEST GERMANY

Phoenix-Rheinrohr A. G. consists of a number of plants along the Rhine and Ruhr Rivers. The principal component is the modern Ruhrort plant at Duisburg. An older steel plant is at Mulheim, while the Dusseldorf plant is devoted to pipe.

Overall, the company has 11 blast furnaces, two sintering plants, two basic bessemer shops, three open hearth shops (17 furnaces), one electric arc furnace, four blooming mills, three finishing mills for structural shapes, merchant bar, track materials and rod, three plate mills, two strip mills for strip, skelp and universal plate, seven Pilger pipe mills, four Stiefel tube mills, three continuous butt-weld tube mills.

Annual capacities are approximately 2,400,000 net tons of iron, 2,750,000 net tons of ingots. Principal products are plate up to 10 in. thick and 170 in. wide, pipe of various types, merchant bar and wire.

August Thyssen-Hutte A. G., at Duisburg-Hamborn, Germany, grew from a modest start in 1890 into an efficient plant of 2,640,000 net tons ingot capacity prior to World War II, and with four other plants in the area, belonged to an operating company. The new company, formed in 1953, has only the Hamborn plant, which was largely destroyed by war damage and post-war dismantling.

Located on the Rhine River, the plant is favored by water transportation for ores from central Germany and from foreign countries. Coal deposits are near the plant.

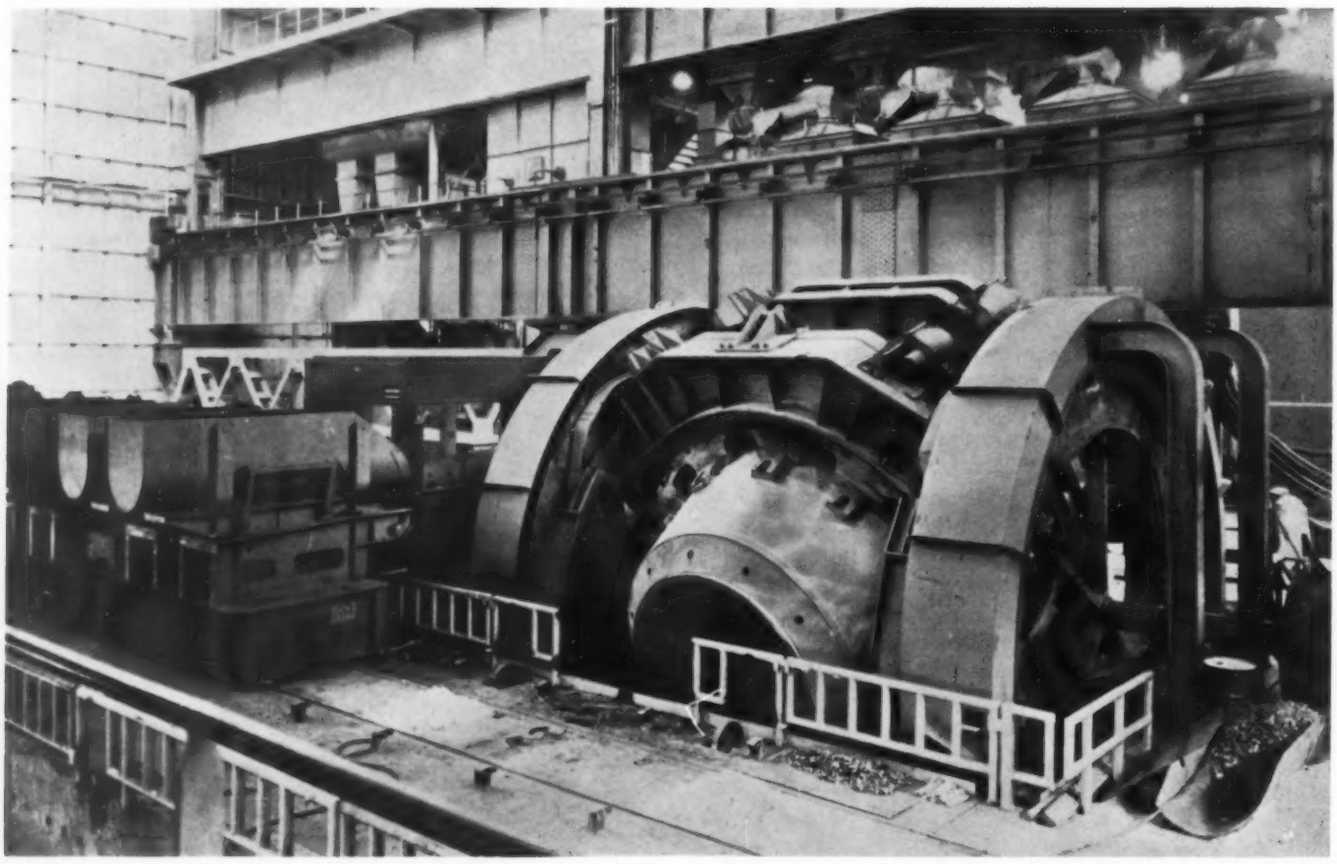
Coke for the eight blast furnaces is produced in 340 by-product ovens grouped into five batteries. The blast furnaces, ranging up to about 29.6 ft hearth diameter, provide an annual capacity of about 242,000 net tons per month. The largest furnace turns out 55,000 tons per month on a coke rate of 1340 lb per net ton.

The blast furnace charge, which runs about 50 per cent sinter, averages 50 per cent Fe.

Steel is made in seven basic bessemer converters (165,000 net tons per month) and in two open hearth shops (110,000 net tons per month.) The old open hearth shop contains six furnaces ranging from 75 to 155 tons in size. A modern shop, built to American designs, contains four 290-ton furnaces which produce at a rate of 33 to 35 tons per furnace hour. They have basic roofs and ends, and are fired with fuel oil atomized by blast-furnace gas compressed to six atmospheres. An oxygen steel converter plant is being laid out.

Ingots are broken down in a high-lift slabbing mill (275 tons per hr) and another blooming mill. Further rolling is performed in a heavy finishing mill, a universal parallel-flange beam mill, a medium section mill and a

The Kaldo vessel rotates on its own longitudinal axis within a supporting cradle which also turns to tilt the vessel. Here the SOLLAC unit is tilted to its blowing position, 17 degrees from the horizontal. A collecting hood carries exhaust gases to a cleaning unit. The scrap charger is shown at the left.



typical modern 66-in. hot strip mill. The strip mill rolls about 130,000 tons per month, some of which goes into cold rolled sheet or galvanized material.

In 1959, this plant turned out 2,653,000 net tons of ingots and 2,090,000 net tons of rolled products, principally strip, rails, beams, shapes and bars. This is approximately nine per cent of West Germany's total.

In the same year the plant employed 12,262 people and paid out $21,200,000 in wages and salaries and $4,740,000 in additional benefits. Estimates based on these figures show about 11.5 man-hours per ton of ingots and about 85 cents total per hour. Sales for the year were given at $258,000,000, which would indicate an average sales price of about $123 per net ton.

This plant works closely with three other companies which were part of the old operating company: Niederrheinische Hutte A. G., Deutsche Edelstahlwerk A. G., and Phoenix-Rheinrohr A. G. A recent move to merge August Thyssen with Phoenix-Rheinrohr was held up by the High Authority of the European Coal and Steel Community.

Huttenwerk Oberhausen A. G. is another Ruhr company that required extensive rebuilding after the war. This was done on the old sites, so the layout is rather congested by American standards. It consists of a steel plant at Oberhausen and a wire mill at Gelsenkirchen.

At Oberhausen there are eight blast furnaces, the largest of which produces about 1500 tons of iron a day. Annual capacity is about 1,650,000 net tons of iron.

Steelmaking facilities include a basic bessemer shop with seven 25 to 35 ton converters, an open hearth shop of five furnaces of 35 to 50 tons capacity, another open hearth with five 150-ton furnaces and one new 275-ton furnace (with another similar furnace to come), and two rotor units.

The rotor installation is of interest, as the process was developed here. One unit is of 66-tons capacity, the other 88 tons. The vessels are essentially horizontal cylinders which can be rotated at one to three rpm and which can be tilted for pouring. Their charge consists of 65 to 70 per cent molten iron and 30 to 35 per cent "cooling agent," which might be 70 per cent scrap and 30 per cent ore, with ore preferred. Also, 80 to 120 lb of lime are charged per ton of charge. Oxygen is introduced through special patented lances immersed in the bath. The process requires a blow of about 20 minutes. A method of fettling and "washing" the lining has been devised to lengthen lining life.

The plant provides monthly capacity for 90,000 to 100,000 tons of open hearth steel, 90,000 to 100,000 tons of basic bessemer steel and 17,000 to 20,000 tons of rotor steel.

Ingots are roughed down in a slabbing mill and a blooming mill, both now driven by steam engines but the former soon to be electrified. These mills are served by a group of new and old soaking pits, some of which are the old individual pits holding one ingot each.

Production is chiefly in plate, structurals, merchant bar, rod and wire.

Future plans of the company include a new blast furnace, new rotor plant, new wire mill and possibly a strip mill. There is at present a small iron powder plant which the company would like to enlarge. A recently completed research laboratory employs 390 people.

Dortmund-Horder Huttenunion A. G. operates two plants which provide a total monthly capacity of 265,000 net tons.

At the Horde plant there are four batteries (217 ovens) of by-product coke ovens. Five blast furnaces can produce about 100,000 net tons of iron per month. Steel to the extent of 140,000 net tons of ingots per month can be made in six basic bessemer converters and two open hearth shops (12 furnaces). Two oxygen steel converters are being installed.

Ingots are first rolled in a blooming mill or a slabbing mill. A billet mill follows the bloomer. Slabs are rolled into plate in one of three plate mills. One of these is a modern unit consisting of two heating furnaces, a 158 and a 118-in. reversing stand, both four-high, in tandem. The other two plate mills are old. There is also a production forge shop and a steel foundry.

At the Dortmund plant, five blast furnaces offer capacity for 105,000 net tons of iron. Five converters can turn out 75,000 tons of basic bessemer steel, while five open hearth furnaces produce about 46,000 tons. Rolling facilities include two blooming mills, a structural mill, a universal plate mill—all old—and a new merchant mill. There is also a forging press.

Combined, the two plants ship about 200,000 net tons of steel products per month.

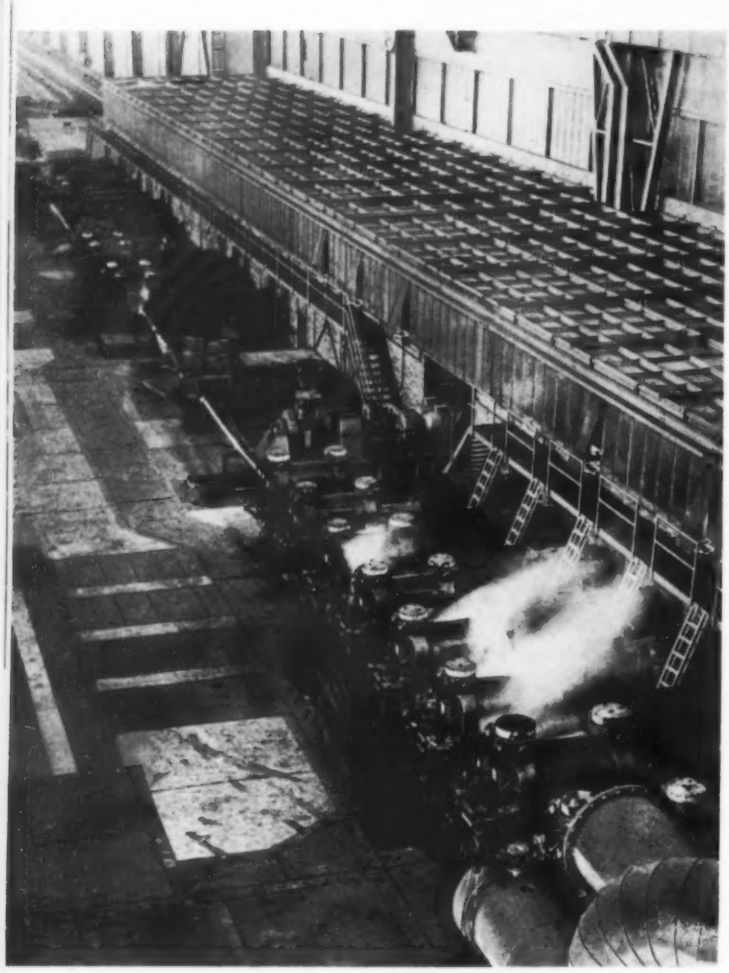
A feature of the Dortmund plant is a degassing unit developed here. A ladle of steel is moved beneath the vacuum chamber. The chamber is lowered over the ladle and a vacuum of perhaps 20 mm of mercury is set up for 15 to 20 min. During the treatment, molten metal is forced into the vacuum chamber in successive portions by a cyclic change in the immersion depth of the suction nozzle. This treatment is said to remove oxygen and hydrogen effectively, and result in the elimination of flakes, cleaner steel and improved pipe conditions. A paper by Harders, Knuppel and Brotzman giving details of this equipment was presented at the 1960 meeting of the AIME Open Hearth Committee.

Two of these degassing units are on order for plants in the United States, and others for Germany and Japan.

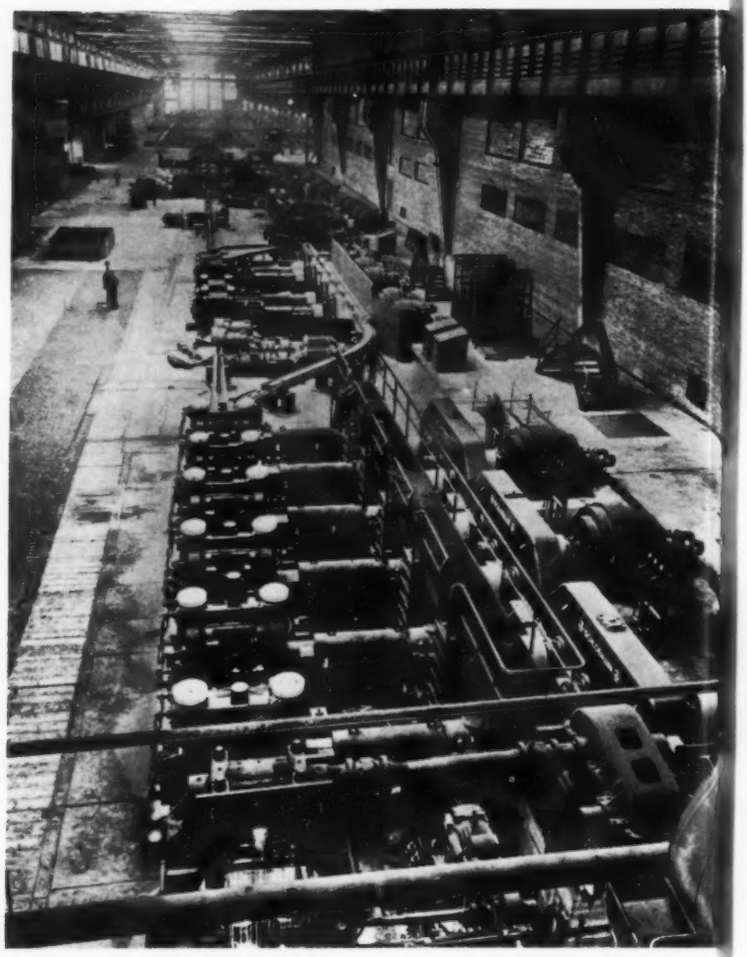
Hoesch-Westfalenhutte A. G. in Dortmund is the operating nucleus of 23 concerns forming Hoesch Werke A. G. It has six blast furnaces, the largest of 26.3-ft hearth diameter. Approximately 60 per cent of the ore comes from Sweden, and 10 to 15 per cent from Germany. The rest may come from Labrador, Africa or South America. A new 110,000-ton-per-month sinter plant will be added to an existing 77,000-ton-per-month unit so as to give about one ton of sinter for each ton of iron produced. Coke consumption in the furnaces runs about 1400 lb per net ton of iron.

Total monthly steel capacity is about 220,000 net tons of ingots. About half of this comes from a four-converter basic bessemer shop, and the remainder from 11 open hearth furnaces and an electric arc furnace. The open hearths are in three separate shops and range from 25 to 200 tons in size. An oxygen steel converter plant is being planned.

There are two old blooming mills, one followed by a new continuous billet mill consisting of six horizontal stands and six vertical stands. There are also a heavy structural mill, a medium structural mill, a merchant



This straightaway merchant mill at Huttenwerk Oberhausen A. G. is typical of the modern installations found in European steel plants.



This new merchant mill at Hoesch-Westfalenhutte A. G. is highly flexible, with a roughing train (foreground), two parallel intermediate trains and two parallel finishing trains, with the necessary cross-over switches.

mill, an old rod mill and a new combination merchant mill of very flexible layout.

In a separate location there is a reversing universal mill which roughs ingots into slabs. It is followed by two reheating furnaces, a reversing rougher and a five-stand hot strip finishing train. A sixth finishing stand is to be added. The finishing train replaced two hot Steckel mills which formerly rolled breakdowns from the rougher into strip.

Because the mill is built over coal mines, the finishing train is mounted on a huge concrete pad which can be leveled by hydraulic cylinders to compensate for ground subsidence.

There are at present two reversing cold mills, to which will be added a tandem mill. Electrotinning and wire drawing facilities have also been provided.

Huttenwerke Ilsede-Peine A. G., in northern Germany, is a subsidiary of the Ilseder Hutte, with its own local ore mines. Although only about 25 per cent Fe content, the ore is said to give a cheaper iron charge than is available in the Ruhr. The ore is washed and part of it is sintered. Coal, however, is more expensive than in the Ruhr.

A feature of this plant is the rotor installation, which consists of two vessels but only one mounting, so that only one vessel works at a time. The charge consists of 20 per cent scrap and 80 per cent iron of 2.0 per cent or more phosphorus. 1.8 per cent manganese and 10 per cent lime. The oxygen blow takes about 45 min. Four or five heats of 65 to 75 net tons are made per day. Some trouble has been experienced with the roller units on which the vessel rotates. Also, lining life had been only about 50 heats. Tests will be made with oxygen lances of two different lengths to try to spread out lining erosion, which seems most heavy around the ends of the lances.

Steel is also made in a basic bessemer shop and three 40-ton open hearth furnaces. Monthly production runs about 77,000 net tons, with 5500 tons from the rotor, 5500 tons from open hearths and the remainder bessemer.

Iron comes from six small blast furnaces located about six miles from the steel plant.

Rolling facilities include a new soaking pit installation, an old bloomer and beam rougher, and four new structural stands. Product is chiefly structurals and bars.

The company is planning the installation of two LD-AC vessels. When these come into production, some of the open hearths and bessemers may be shut down. Plans also include a new merchant mill so designed as to reduce roll changing time. A new rod mill is also under consideration, to be built, perhaps, as a joint venture with Huttenwerk Salzgitter A. G. ▲

A-C Torque Motors for Steel Finishing Lines

by L. H. BERKLEY, Reliance Electric and Engineering Co., Cleveland, Ohio

A-c torque motors can be used as a simple, economical means for coiling light or heavy mill strip . . . . they fit into the range between mechanical slip-clutch devices and very accurately regulated large d-c drives.

DURING the past decade there has been much written about new and improved methods of obtaining adjustable-speed drives. This paper concerns the application of an old and established family of motors having the unique faculty of varying, if not adjusting its own speed. This ability is too often ignored, when it could be used to advantage, both economic and operational. These motors are torque motors—motors so old that everybody has forgotten about them.

A-c and d-c torque motors are not new. They have long been used for supplying a stalled torque and for coiling purposes in the rubber and plastics industry, the wire industry and in the steel industry, but generally for light gage material; for example, wire and for paper recoilers on stainless steel lines. Over the past six years, however, these motors have found a new place in coiling heavy, as well as light, strip. They have proven to be particularly advantageous on continuous multiple-strip lines.

PRINCIPLES OF OPERATION

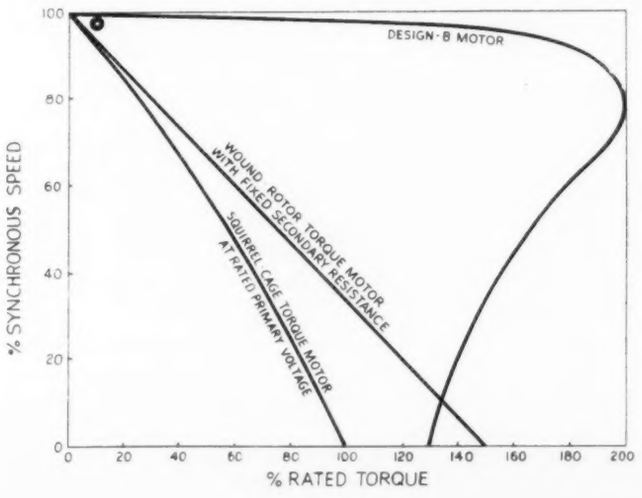
The main advantage of a torque motor for coiling purposes is its varying speed characteristic; that is, speed decreases as load is increased, preferably along a straight line. In a-c parlance, this is called a high-slip characteristic, as shown in Figure 1. Such a characteristic is obtained from either a wound-rotor motor with resistance inserted into the secondary, or a squirrel-cage motor with a high-resistance rotor.

Conversely, as speed is decreased by an external stimulus, the torque developed by the motor increases. It is this effect that is utilized for coiling strip and to provide a satisfactory tension during this coiling.

A stripped-down process line is shown in Figure 2. It consists of the pay-off, the process equipment, a bridle stand or pinch roll if necessary, and the coil. The bridle stand or pinch roll may serve to maintain constant line speed against the pull of the torque motor, if this function is not fulfilled by the pay-off or a drive on the process equipment. Or these rolls may serve as a tension "break," if the process tension must differ from the desired coiling tension. Or the bridle supplies the power to pull the material through the equipment, and the torque motor supplies only coiling tension. The bridle stand may be ahead of the process equipment if process tension is not critical. In any case, the torque motor requires a constant line speed and something to pull against.

As the coil builds up, its diameter and circumference increase. Because line speed is held constant, the torque motor slows down, neglecting elongation. As the motor slows down, it follows along its torque-speed curve and develops greater torque. But its lever arm (the coil radius) is greater, and hence, the coil tension remains relatively constant. Constant tension at constant line

Figure 1 — Basic torque-speed curves of a-c motors.



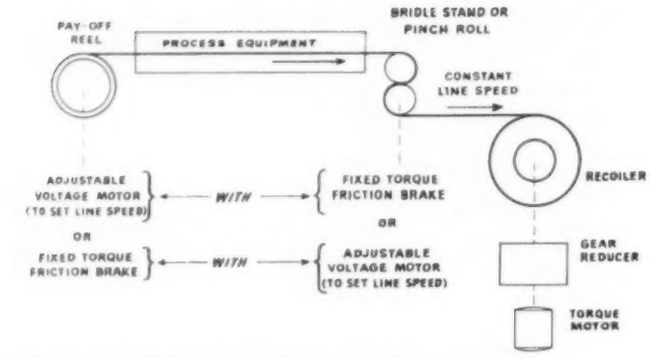


Figure 2 — Schematic shows simple process line.

speed is, of course, constant horsepower.

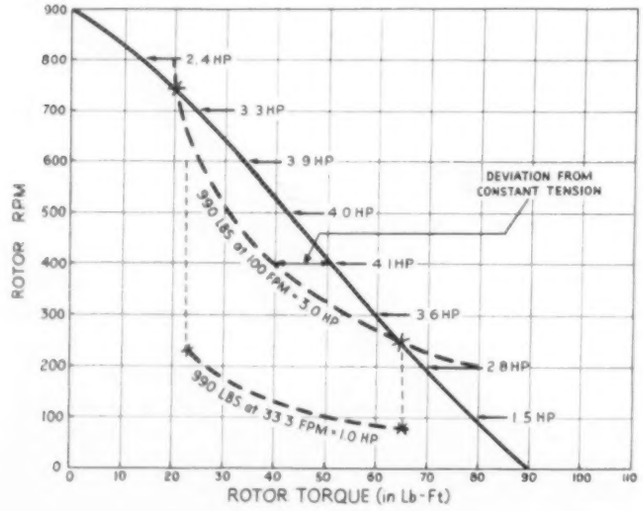
This effect can be seen in Figure 3, an actual performance curve of a squirrel-cage motor developing 90 lb-ft at full-voltage stall. Assume the strip requires 990 lb of tension, and is being processed at 100 fpm, this being fairly close to an actual case. The constant horsepower required during coil build-up is 3.0 hp. The torque motor develops this horsepower or more from 730 rpm (22 lb-ft) to 240 rpm (66 lb-ft), the overall speed range being roughly three to one. In other words, the motor can handle a coil build-up of roughly three to one with reasonably constant tension.

Now what is meant by "reasonably constant tension," and how much is the deviation? This can be seen in Figure 3. Ignoring friction in the drive, at empty coil (730-rpm rotor speed) and at full coil (240-rpm rotor speed), the tension will be exactly the desired 990 lb. But at mid-coil, 485 rpm the motor will develop 4.1 hp. The coil tension will be 4.1/3.0 x 990 lb, or 1350 lb, which is 32 per cent more than desired. In the majority of cases where strip is coiled, this is acceptable.

LOW-SPEED OPERATION

Now suppose the line were running at ⅓ speed, or 33.3 fpm. The constant horsepower requirement would be as shown in the lower half of Figure 3. At empty coil, actual tension would be triple the desired tension (3.0 versus 1.0 hp), and at full coil, actual tension would be 40 per cent greater than desired (1.4 versus 1.0 hp). To correct this situation, the voltage on this squirrel-cage motor can be reduced as the coil builds up. This is shown in Figure 4, which shows the process requirement for 33.3 fpm.

Figure 3 — Performance curve of a torque motor for coiling service.



Adjusting the input voltage to the squirrel-cage motor by means of an adjustable-voltage transformer gives a family of curves providing different torques. The voltage in our example could be set at 340 volts to give a tension of 1750 lb at the center of the coil, gradually decreasing to 750 lb at the outside wraps. This has the advantage of being tighter on the inside, which prevents telescoping.

Or, the operator can periodically adjust the voltage as the coil builds up, to maintain what he thinks from experience is the best tension for a "good" coil. This is entirely feasible on multiple strip lines, where coils are often of different lengths, are checked from time to time, and are removed individually. But observation indicates that when operators start a new run on a certain size of strip, they usually set the voltage and leave it at that value while running a large number of identical coils. However, automatic and continuous tension regulation may sometimes be provided.

A similar family of curves can be obtained by using a wound-rotor motor with adjustable secondary resistance. Torque motors can be supplied from an adjustable-frequency source, to provide performance admirably suited to coiling service. The adjustable-frequency alternator could be driven from the bridle motor.

TYPES OF TORQUE MOTORS

The basic trait of a torque motor is simply "high slip." It is equally simple to enumerate the several basic types of industrial motors that can be made to exhibit this trait and, join the torque motor family:

1. A squirrel-cage induction motor, certainly preferred in the smaller ratings, sometimes built with a fabricated copper-bar rotor and sometimes blower-cooled.

2. A wound-rotor induction motor, sometimes preferred in the larger sizes, with resistance in the secondary, fixed and/or adjustable to give various torque-speed curves.

3. A d-c motor, either heavily compounded or series-wound for constant strip speed, limited build-up applications; shunt motors with adjustable armature circuit resistance for adjustable strip speed.

This paper concerns a-c motors primarily, but d-c torque motors are advantageous in some cases.

The selection of either the squirrel-cage or the wound rotor motor depends on a number of factors, of which the most important is the basic difference between the two. This difference is location of the high rotor or secondary resistance, which both motors must have to obtain the high-slip characteristic. In the squirrel-cage motor, the resistance is within the motor; in the wound-rotor motor, the resistance is brought out through slip rings and brushes. This basic difference leads to the other differences, which are:

1. A torque motor is an electric slip device and, therefore, generates heat. In the squirrel-cage motor, this heat is built up within the motor and must be disposed of, either by self-cooling or blower-cooling. In the wound-rotor motor, this heat can be dissipated outside the motor.

2. Because of this heat, wound-rotor motors can

often be built in smaller frames, particularly for larger coiling horsepowers. Blower cooling is usually required for squirrel-cage coilers above one hp (coiling hp), but except for prolonged slow-speed operation (a wide linear range plus a large build-up) is not usually required for wound-rotor motors.

3. But frame for frame, the squirrel-cage motors are considerably less expensive.

4. Where acceleration time is a factor, the lower rotor inertia of the often smaller wound-rotor motor may dictate its use.

5. The smaller wound-rotor motor, with fewer secondary slots, may run with a jerky "slotting" action at slow speed.

6. Where environmental conditions dictate totally-enclosed motors, the wound-rotor motor may be the best solution, again because of heat.

7. Cost of control to obtain adjustable tension or steps of tension is lower for wound-rotor motors in larger ratings.

8. Cost of maintenance of the squirrel-cage motor, with its absence of brushes and slip rings, is almost negligible. It is comparable to that of any general-purpose, low-slip squirrel-cage motor.

As a general summary, squirrel-cage motors are preferred in the smaller sizes and wound-rotor motors in the larger sizes. The break-even point is somewhere between 5 and 10 coiling hp, the choice depending on the factors already listed.

CONSIDERATION OF TENSION

How critical is tension? This question naturally arises, since with an unregulated torque motor, tension can vary over at least a two-to-one range. On a particular application in 1953, the question arose. A steel company specializing in multiple-strip operations was considering the addition of two new finishing lines. The first was a galvanizing line capable of handling simultaneously up to thirty individual strips of widely varying sizes, at speeds of up to 200 fpm. The second was a slitting line with twelve individual coilers, with line speeds of up to 1000 fpm. With such a large number of coilers involved, it was desirable to compare thoroughly some of the applicable methods of coiling. Should the coilers be driven by mechanical adjustable-speed transmissions with mechanical slip clutches? Or does each coiler require a regulated d-c motor, the most expensive system but certainly the one giving the most constant coiling tension? Or could torque motors do the job?

Examination of the coilers on an older, existing galvanizing line provided part of the answer. The coilers were driven from the bridle by a series of flat belts and pulleys, with compensation for coil build-up provided by slippage of the belts against the pulleys. This system produced coils that could be utilized and shipped satisfactorily. However, tighter and larger coils were desired.

The nature of the galvanizing operation is such that each strip is coiled, cut, tied and removed by operators, who then start a new coil while the line continues to move. The operators are also the judges of proper tension.

At this point, a series of tests were run over a three-month period to determine if torque motors were feasible. The steel company had an old high-slip motor and, with the aid of a few tests to determine its torque-speed curve and a fan to keep it cool, it was used as a torque motor in running the tests. A "good" coil was defined as one that was tight enough to be handled by fork truck, conveyors, and other usual shop methods; tight enough to support its own weight without bulging at the middle when stored upright; tight enough so that it would not telescope, yet have no "coil set," or stress beyond the yield point. After each series of tests, the coils were examined carefully and then taken apart, often wrap-by-wrap, to see if they fulfilled these criteria. The tests were run at a constant line speed of 350 fpm. Materials were changed from 0.275 × 0.011-in. stainless to 3 × 0.050-in. strapping, low-carbon steel.

The tests yielded several interesting results, in brief:

1. Different men have different ideas as to how much tension is required for a good coil. There were cases where one operator would coil heavier material at a lighter tension and another operator would coil lighter material at a heavier tension. Both produced good coils.

2. The actual tension could vary from over 15,000 psi for the light strip (0.011) to under 2000 psi for the heavy gage (0.050) and still obtain a good coil.

3. Permissible variation from an optimum tension, which varied with the gage, could be as high as plus or minus 50 per cent. For example, it was concluded that the optimum tension for coiling maximum slitter size, $1\frac{1}{4} \times 0.028$, was 5000 psi but that good coils could be obtained anywhere from 2500 to 7500 psi.

The over-riding conclusion was that barring the one extreme of a "soft" coil (not enough tension) and the other extreme of "coil set," tension is not critical. The final proof of the validity of these tests and conclusions is the fact that the galvanizing lines and the slitting lines in question have been in successful operation since 1954, and subsequent lines have proven equally successful.

CONTROL

Operation and control of torque motors for coiling has thus far been discussed only in relation to the steady state operation. But acceleration and deceleration are always a problem, regardless of the type of drive on the coiler. Uncontrolled acceleration would permit slack between the low-inertia bridle and the high-inertia coil (and torque motor). The coil would eventually catch up with a snap that could cause undesirable tensing or even snapping of the strip. With a torque motor, this problem can be doubly difficult. The torque motor senses slack as no load (neglecting friction) and accelerates up to synchronous speed, even though the line is running at only a slow speed. For example, referring to Figure 4, the line operating at 33.3 fpm may have been stopped momentarily near the end of a coil. Upon restart, the torque motor should return to operation at approximately 100 rpm rotor speed. Instead, if there is sufficient slack, the motor can accelerate up to 900 rpm—nine times the linear speed of the line—so that when it catches up, it does so with a "bang." Prevention of such transient occurrences is perhaps the most important requirement in applying torque motors. Making the motors "behave themselves" is a control function, and the successful application of torque motors depends much on the control. Some of the control techniques used with torque motors are

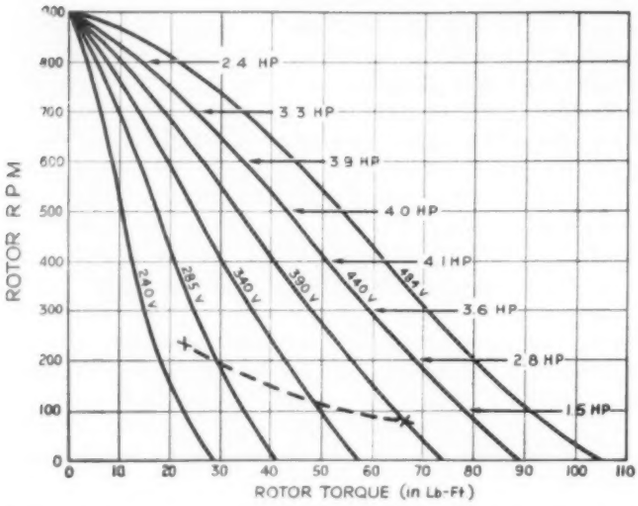


Figure 4 — Adjusting input voltage produces a family of curves.

admittedly the result of trying to duplicate the extremely desirable performance characteristics of fully regulated d-c lines. Specific control techniques vary, but all provide to some degree the following:

1. Controlled acceleration and deceleration of the entire line, the torque motor being controlled during these periods so as to eliminate or minimize slack. Process line operation requires adjustable speeds. The use of control acceleration and deceleration is common practice, and adds no complexity.

2. Stall tension of the torque motors prior to acceleration to operating speed, and a return to stall tension if the line is halted for a period of time. Again, provision of stall tension is common practice. Most of the control circuitry for this feature is required for other drives in the line.

It appears that control of torque motors leads to a successful marriage of direct current and alternating current; direct current to control the process and line speed, and alternating current to coil the products.

With squirrel-cage motors, stall tension can be provided in several ways:

1. An auto-transformer to provide a lower stall tension voltage. The first step in acceleration is to switch from stall to run voltage, and vice versa during deceleration.

2. A reactor or resistor in series with the torque motors, in for stall and shorted for run.

3. Where a motor-driven, adjustable-voltage auto-transformer is used for common control of all the torque motors, voltage is gradually increased from "stall" to "run" voltage during acceleration, and vice versa during deceleration. Control of the auto-transformer can be timed or regulated.

Most process lines also feature some degree of tension control, either in steps or stepless, if the sizes of strip vary over a wide range. The motors can be adjusted as a group (through a group auto-transformer) and/or individually (through small individual auto-transformers or rheostats).

Squirrel-cage torque motors can be adequately protected by temperature-sensitive thermostats in the stator winding.

Similar control techniques can be applied to the secondaries of wound-rotor motors.

ADVANTAGES AND LIMITATIONS

Torque motors fit in as one of a number of other coiling techniques. Some of these are:

1. Constant-speed motor with slip clutch.
2. Constant-speed motor with a mechanical adjustable-speed transmission and slip clutch.
3. Hydraulic mechanisms.
4. Eddy-current slip devices.
5. Fully regulated d-c motors or other drives.

Compared to these, torque motors have certain advantages and limitations, economic and operational, the sum of which gives them a wide field of application. As a guide to this field, the following generalizations can be made.

First cost—A-c torque motors and their control are in most cases less expensive than fully regulated drives of any type, either d-c motors, or eddy-current or hydraulic devices. This is perhaps over-emphasized, since torque motors are limited to lower ratings, where the cost of regulating control is proportionately high. The first cost ratio between torque motors and fully regulated drives can be as much as two-to-one.

Torque motors are comparable cost-wise to a coiler combination of a constant-speed motor, adjustable-speed mechanical transmission, and mechanical slip clutch; or a combination of a constant-speed motor and an unregulated eddy-current clutch. But they are more expensive than a constant-speed motor plus mechanical slip clutch only; this drive is limited to a narrow product of line speed range and coil build-up.

Simplicity of control—The components required to control a-c torque motors are quite simple—contactors and auto-transformers. Run tensions are quickly and easily adjusted for the group of coilers or individually. Individual control makes it possible to run a number of different sizes on different coilers, each coil being set for the particular tension desired. On the other hand, a mechanical slip clutch is a constant-torque device, set to slip at a fixed torque. Tension decreases directly with build-up, unless mechanical or pneumatic adjustment is provided. Fully regulated drives, of course, provide constant tension automatically without further adjustment by the operator.

Maintenance—Squirrel-cage torque motors and their control require less maintenance than any type of coiler drive. The components are fewer and simpler. Wound-rotor motors approach this, except for the addition of slip rings, brushes, and a wound rotor.

Mechanical slip clutches are, of course, subject to wear and their lining must be replaced periodically. The "lining" of the torque motors is the air gap.

Tension variation—Where coiling tension is critcal and must be maintained within narrow tolerances, there is no substitute for a fully regulated drive. For coiling such materials, torque motors or other types of clutches are generally not adaptable.

But torque motors are fully capable of handling a large variety of metal strip. On slow-speed lines, variations can be conveniently minimized by the operators.

Power consumption—A torque motor, being a slip device, wastes power. This power waste, plus the fact that at least part of it is dissipated within the motor, limits the size to where power costs do not become an important factor.

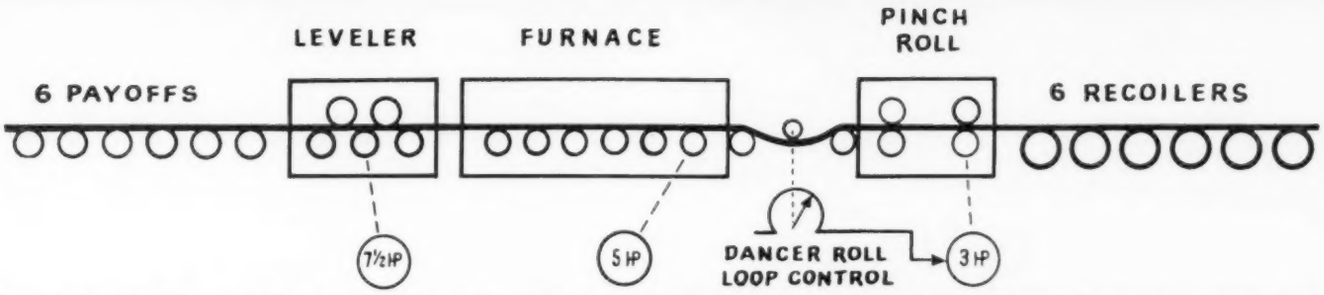


Figure 5 — This furnace line has six torque motor recoilers. Because of the three adjustable-speed motors required for process control, had the line required only a single coiler, it would undoubtedly have been d-c. This line is unique in its slow-speed operating range of 1 to 10 fpm for material up to 7-in. wide, gage 0.022 to 0.145 in., and coil build-up of 24/48-in. diameter. Because of the slow line speed, the motors have a synchronous speed of 300 rpm, and the gear shaft a synchronous speed of 2.04 rpm.

Size Limitation—In small coiler ratings, the simplicity of torque motors and their control give them a decided economic advantage over regulated motors. First, because the cost of regulation is almost as great for small units as for large; and second, small ratings, despite the heat loss, can be built in small sizes. As coiling horsepower increases, the relative cost of regulating control decreases and the relative cost of torque motors increases. No set economic limit can be given for torque motor horsepower; this depends on the number and types of other equipments in the line.

Number of coilers—Consider, for example a single-strip line consisting of a leveler, furnace, and pinch roll, each driven for process reasons by an individual adjustable-speed d-c motor, with the line speed regulated. The bulk of the equipment is already d-c. The question of whether the single coiler should be a-c or d-c would be decided in favor of the d-c motor perhaps a d-c torque motor, or perhaps a tension-regulated device.

Next consider the same line, except that a number of strips are to be run simultaneously and individually coiled. It is obvious that the greater the number of coilers, the more attractive become a-c torque motors.

Such a line is shown in Figures 5 and 6. These and subsequent illustrations indicate the wide range of usage to which a-c torque motors have and can be put.

Mechanical flexibility—Torque motors, largely because of the simple squirrel-cage construction frequently used, lend themselves to a variety of mechanical modifications. For example, the unit can be built as a gearmotor, with a gear shaft large enough to support the weight of the coil. This is done quite frequently, and most of the illustrations cover gearmotors. Likewise, an integral brake can be added on the motor end.

Where light strip is to be oscillated, it is often advantageous to drive the oscillating mechanism at motor shaft speed. A shaft extension can easily be brought out the motor end for this purpose.

Where large heavy coils are built up, the completed coil is pushed off the block onto the fork of a fork truck. This is generally accomplished by a hydraulic push-off mechanism that can be mounted on top of the gearhead. A simple modification of the gearhead pattern accommodates mounting of the mechanism. Figure 7 shows the oscillating mechanism mounted on the coiler and the gearhead mounting for the push-off equipment.

If the block requires a hydraulically operated pushrod for the gripping mechanism, the hydraulic equipment can be flange mounted on the motor end and the push-rod run through the motor and gear shafts to the block itself.

Coilers must sometimes be shifted back and forth to accommodate strip of different widths. The lower section of the gearcase can be modified to take an axle and wheel assembly for this purpose.

This mechanical flexibility has often been advantageously utilized, resulting in a compact, low-maintenance coiler requiring a very minimum of floor space.

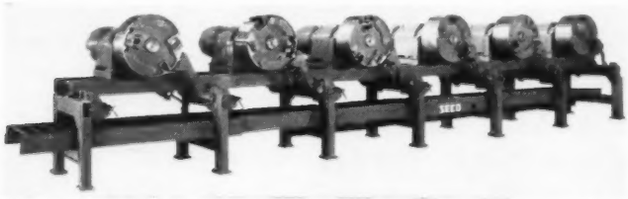
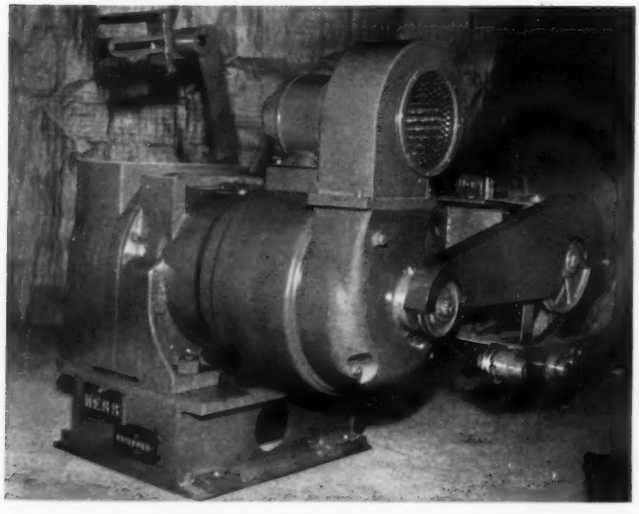


Figure 6 — These six torque motor recoilers are used on furnace line of Figure 5.

Figure 7 — A-c torque motor has oscillating mechanism mounted on the coiler and hydraulic coil push-off mechanism mounted on the gearhead.



SUMMARY

A-c torque motors have long been neglected as a simple, economical, but completely effective means for coiling light or heavy metal strip. True,they inherently cause some variation in coiling tension, but this variation has proven to be permissible and virtually unnoticeable in all cases considered. Torque motors fit a broad niche between mechanical slip-clutch devices and extremely accurate, regulated d-c drives of large horsepower ratings. Torque motors can be used on a wide variety of sizes, and are most advantageous on multiple-strip finishing lines. ▲

Control of Alloy Carryover In Melting

by K. M. SHUPE, Senior Research Metallurgist
and P. DUFRESNE, Supervisor, Procedures and Data Analysis, Latrobe Steel Co., Latrobe, Pa.

. . . . proper selection of sequence of melting of alloy steels can be determined with a melt-sequence table . . . .

THE Latrobe Steel Co. produces a wide range of high speed, tool, die, specialty and stainless steels in the electric furnace. With such a wide range of analyses, it was necessary to develop a system of controlling melting sequences to eliminate unwanted alloy carryover of such elements as cobalt, chromium, nickel and tungsten from one heat into the following heat where the element might not be desired. Excessive carryover results in the high costs of missed analyses, missed deliveries and scrapped heats.

The problem of suitable sequencing was made more critical when rammed furnace bottoms were installed. Rammed bottoms give increased bottom life thus seriously limiting the capacity to melt low residual grades. Some low residual grades had been specified as workable on new bottoms only. Under any circumstance, the nature of the tool steel business does not allow long campaigns in melting of similar grades.

It was the authors' object to systematize the scheduling of steel heats by analysis type. The ultimate aim was to make the system workable by nontechnical scheduling personnel. The end product of the program

Figure 1 — The table makes it possible for nontechnical personnel to make decisions on grade sequence.

MELT SEQUENCE TABLE — PART A, HIGH SPEEDS

FIRST HEAT GRADES	FOLLOWING HEAT GRADES: E. No. 1	E. No. 5	E. No. 19	E. VANADIUM	E. U	E. DYNAVAN	E. COBALT	E. S COBALT	E. U COBALT	E. TAT. COBALT	E. CRUSADER	E. CORSAIR	E. TATMO	E. TNW	E. LACOMO	E. 6-6 (E-7)	E. MV-1	E. MV-2
E. No. 1										P			N	N	N		N	P
E. No. 5										P			N	N	N		N	P
E. No. 19										P			N	N	N		N	P
E. VANADIUM										P			N	N	N		N	P
E. U										P			N	N	N		N	P
E. DYNAVAN	N	N	N	N	N					P	N	N	N	N	P	N	N	N
E. COBALT	N	N	N	N	N					P	N	N	N	N	P	N	N	N
E. S COBALT	N	N	N	N	N					P	N	N	N	N	P	N	N	N
E. U COBALT	N	N	N	N	N					P	N	N	N	N	P	N	N	N
E. TAT. COBALT	N	N	N	N	N	N	N	N	N		N	N	N	N		N	N	N
E. CRUSADER	N	N	N	N	P	N	N	N	N								N	
E. CORSAIR	N	N	N	N	P	N	N	N	N								N	
E. TATMO	N	N	N	N	N	N	N	N	N								N	
E. TNW	N	N	N	N	N	N	N	N	N								N	
E. LACOMO	N	N	N	N	N	N	N	N	N		N	N	N	N		N	N	N

LEGEND: Blank — OK TO FOLLOW
N — NOT POSSIBLE TO FOLLOW
P — POSSIBLE-TROUBLE MEETING SPEC. EXPECTED

was a melt sequence table (Figure 1) which allows non-technical personnel to make routine decisions on acceptable and nonacceptable grade sequences. The table ordinate is a grade list representing the last grade in the furnace. The table abscissa shows the grade list representing the next grade to be melted. The entries represent:

N—not possible to melt
P—(possible) not recommended to melt
Blank—ok to melt

The entry "P" states that some judgment will be required before scheduling the sequence. For example, allowances must be made for such variables as working temperatures and the number of heats of a particular analysis melted in the sequence immediately before the heat in question. The full table lists each of the nearly 200 active grades.

The melt sequence table is used in the following manner: Reading horizontally, grade E-1 (a T-1 type high speed) may be followed in a melting sequence by E-1, E-5 (an H-26 type hot work die steel) or by E-19 (a T-2 type high speed) but trouble would be expected if E-1 were followed by E Tatmo (an M-1 type high speed) or by E Lacomo (an M-30 type high speed). Trouble would be assured if E-1 were followed by E TNW (an M-10 type high speed).

The development of the melt sequence table was possible only through the establishment of a melt sequence curve (Figure 2) which is the fundamental rule or basis for the table. The abscissa of this curve indicates the per cent content of the listed elements in the original heat and the ordinate shows the per cent content of the listed elements specified in the following heat. Alloying elements included are chromium, nickel, molybdenum, tungsten, vanadium and cobalt.

The curve will convey information for two distinct conditions: (1) where the following heat has the element in question specified, and (2) where the following heat does not have the element in question specified. In the first condition; the two-dimensional area of the graph is utilized, and in the latter condition the strip along the abscissa is utilized. Each of these areas contains three fields: ok to melt; not recommended to melt; not possible to melt.

The curve is used by considering one element at a time. For example, using the main area of the curve, suppose a heat has been melted which contains 9 per cent tungsten. The curve shows that a heat containing much lower tungsten can follow if it has a maximum of at least 1.5 per cent tungsten. The curve further shows that trouble will probably occur when following a 4 per cent cobalt heat with a grade calling for less than 1 per cent cobalt and that a 5 per cent chromium heat should never be followed with a grade specifying 0.75 per cent maximum chromium.

For our purposes, the "no specification strip" indicates that negligible carryover will be obtained if a 1 per cent nickel heat is followed by a grade having no specification on nickel.

The curves are based on the knowledge that in about 90 per cent of the cases the elements chromium, nickel, molybdenum, tungsten, vanadium and cobalt in the operating ranges studied do not exhibit a carryover of more than 10 per cent of the amount present in the first

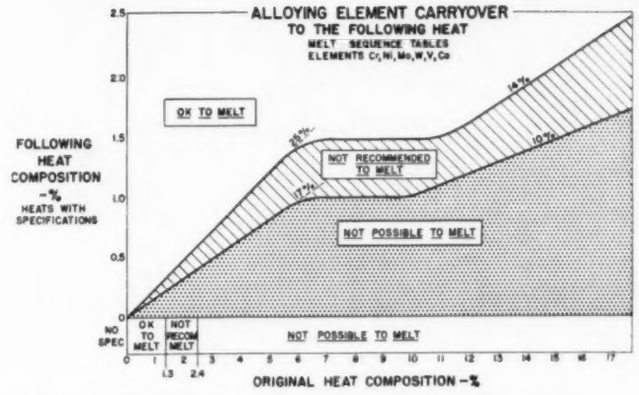


Figure 2 — The curve is the fundamental basis of the melt sequence table.

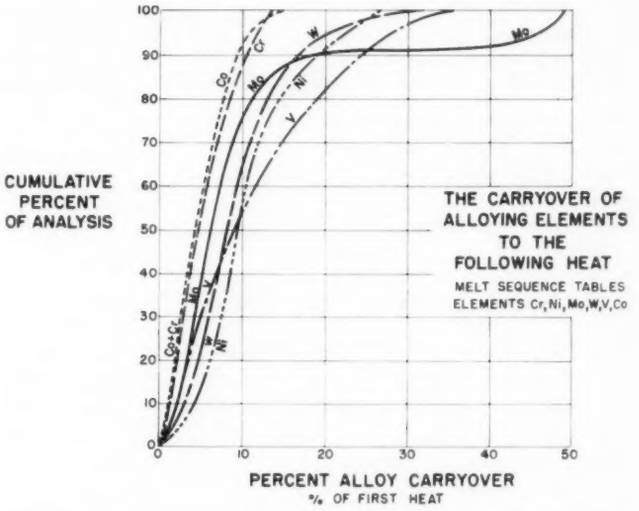

CUMULATIVE PERCENT OF ANALYSIS
THE CARRYOVER OF ALLOYING ELEMENTS TO THE FOLLOWING HEAT
MELT SEQUENCE TABLES
ELEMENTS Cr, Ni, Mo, W, V, Co
PERCENT ALLOY CARRYOVER
% OF FIRST HEAT

Figure 3 — Establishment of alloy carryover percentages during actual melting was necessary.

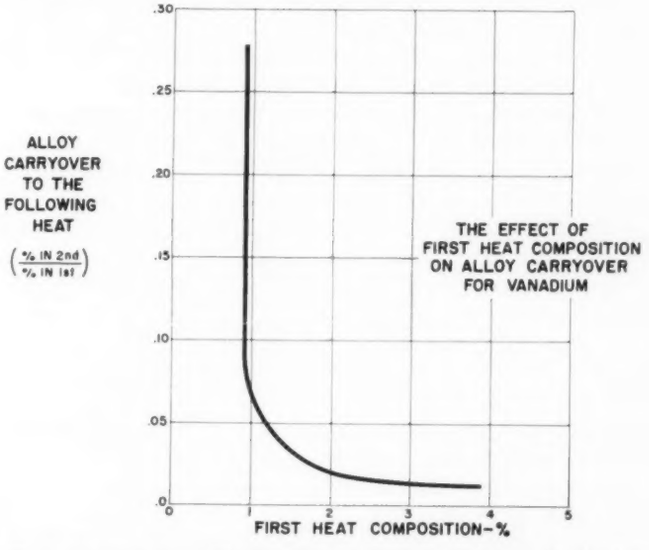

ALLOY CARRYOVER TO THE FOLLOWING HEAT
(% IN 2nd / % IN 1st)
THE EFFECT OF FIRST HEAT COMPOSITION ON ALLOY CARRYOVER FOR VANADIUM
FIRST HEAT COMPOSITION-%

Figure 4 — A vanadium carryover graph shows that the percentage carryover from a heat containing less than one per cent is unpredictable.

heat. The knee of the curve suggests correctly that there is a larger per cent carryover at lower levels of alloy content than is experienced above 10 per cent. This will be discussed further.

This curve is based upon completely empirical experience at Latrobe Steel and is a composite of raw material and furnace bottom carryover. It is expected that a

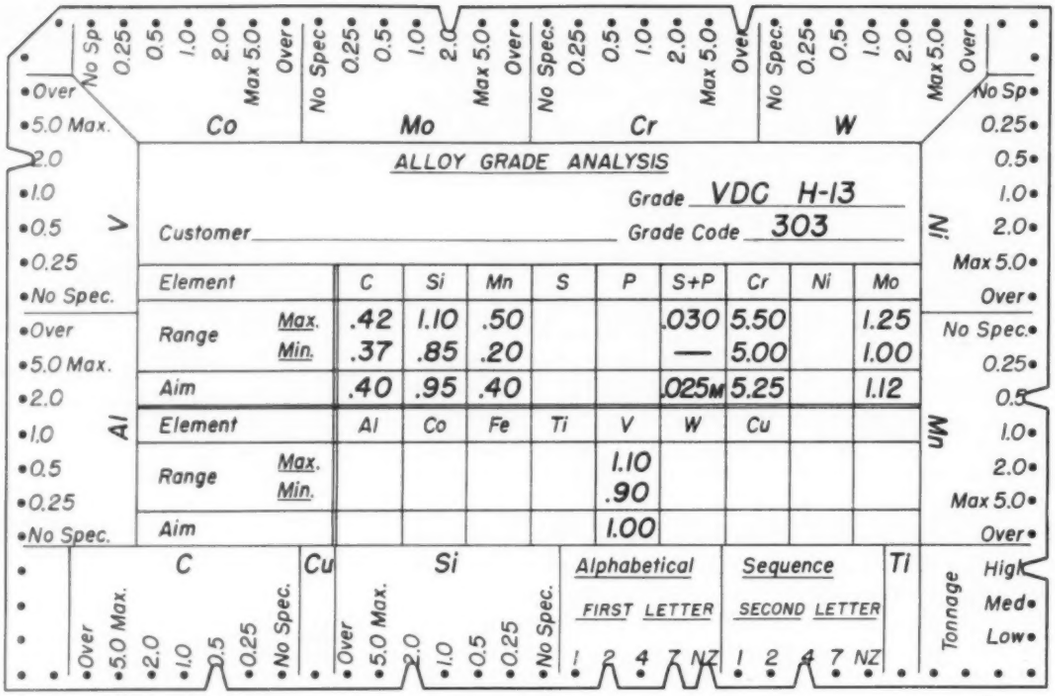


Figure 5 — A special punched card was used to sort sequences to develop melting order table.

more extensive study would suggest a flattening of the curves above 10 per cent alloy content of the original heat. There are strong indications that the curve is quite conservative in this area. In any case, other melt shops with different standard charge mixes, melting practices, furnace bottoms and raw materials might require adjustments for optimum use of this system.

The values 10, 14, 17 and 25 per cent shown on the curves (Figure 2) were determined by an analysis of actual melting sequence analytical information, by a review of sequences leading to missed heats and by analyzing wash heat pickup. Results of this empirical data were plotted (Figure 3) as a cumulative per cent of heats with carry-over of less than the amount indicated by the curve. For example, in 90 per cent of the heats it was found that certain elements such as cobalt and chromium did not exceed 10 per cent carryover of the amount present in the first heat, while the other elements (tungsten, nickel, molybdenum and vanadium) exhibited carry-over up to about 25 per cent of the amount present in the first heat under certain conditions and at certain alloy levels. For instance, the vanadium line shows that we can expect no more than 10 per cent carryover into the following heat 55 per cent of the time or no more than 20 per cent carry-over 83 per cent of the time. The melt sequence curve (Figure 2) is associated with this curve at the 90 per cent level.

The high level of carryover of vanadium and molybdenum were surprising. Investigation showed a pronounced relationship of first heat analysis and its effect on the carry-over of an alloy to the following heat. Figure 4 shows a typical plot of the effect of first heat analysis. A larger per cent carryover is always associated with lower levels of alloy content where most of the tonnage steel producers operate. Vanadium carryover above 2 per cent in the first heat is shown to be quite predictable and will be in the order of about 2 per cent of the amount present in the first heat. On the other hand, carryover of vanadium below the 1 per cent level is highly unpredictable and a carry-over of 25 per cent may be expected occasionally. The saving grace in this case is that for our purpose there is seldom concern about carryover of 10 per cent or even 20 per cent of a 1 per cent vanadium analysis.

While all of this information was very important in establishing the basic curves, the fact remained that to construct a usable table of "ok to melt" and "not possible to melt" for each grade combination to be encountered it was necessary to sort about 200 first grades times 200 following grades for each of six different elements. About 200,000, plus, decisions must be made to arrive at the final table entry of ok, not possible or not recommended. The most practical means available was a series of cards wherein each grade had its analysis, grade name and other data punched into the edge (Figure 5).

For convenience the cards could be sorted into alphabetical order to find a given grade or could be sorted on intervals of chemical analysis such as "no spec," up to 0.25 per cent, up to 0.5 per cent, up to 1.0 per cent, etc. With a given first heat analysis, all other grades could be sorted on the basis of the sequence curves (Figure 2.)

If the first heat were to contain 8 per cent tungsten, all other cards would be sorted so that grades with under 1 per cent tungsten would be placed in a "no" pile, above 2.0 per cent in a "yes" pile and the few remaining cards would be hand flipped into "yes" down to 1.5 per cent and "not recommended" 1 to 1.5 per cent. Sorts would then be made on chromium and other elements. A "no" for any single element would place a grade in the "no" category on the table.

The end result was a table (Figure 1) which can be used for routine decision making in the scheduling of a wide range of steel analyses by nontechnically trained personnel. The principles used here can be adapted to good use in any melt shop where a range of grades produces a problem in alloying element carryover. ▲

Induction Heating of Alloy Steel for Rolling

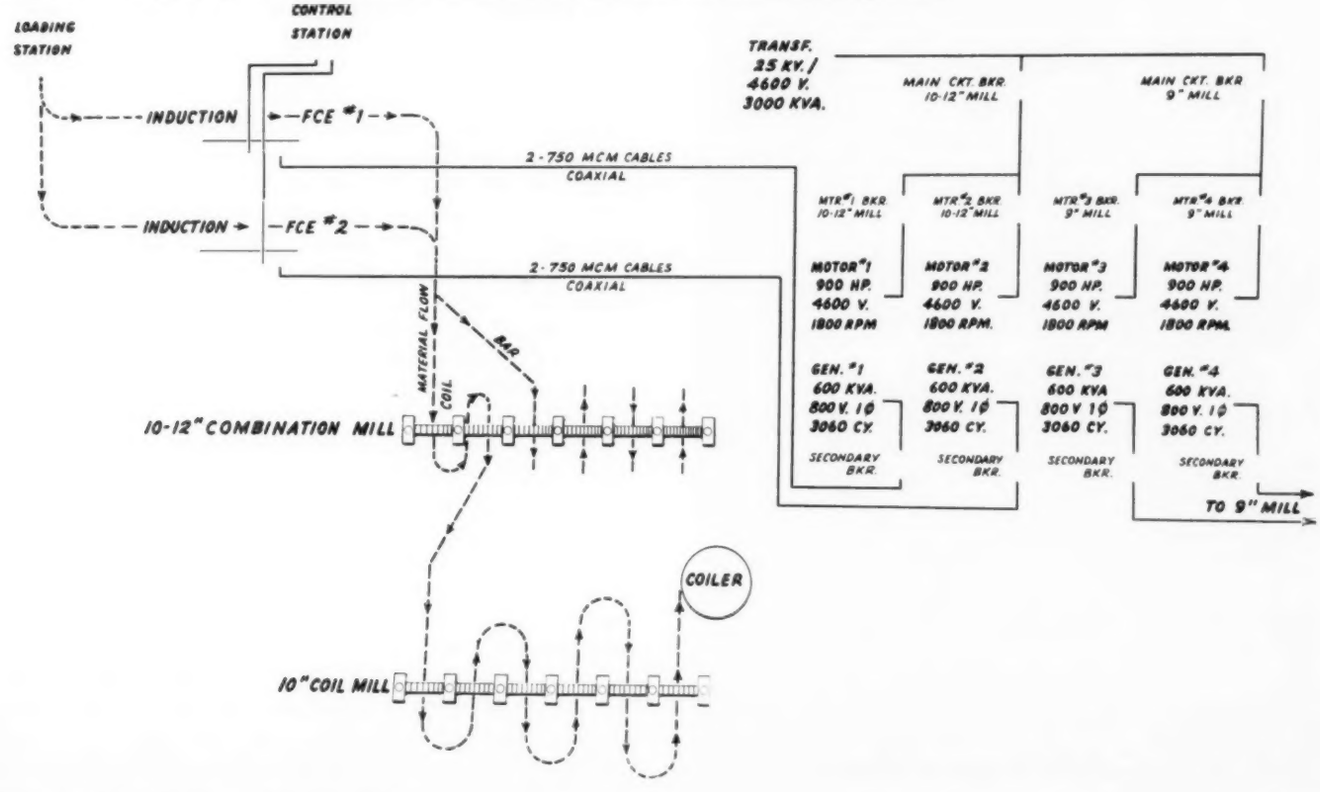
by ROY H. NEER, Works Engineer, Latrobe Steel Co., Latrobe, Pa.

. . . . Latrobe Steel Co. has found results of heating alloys with induction equipment so favorable that they expect that all of their mills will be so operated in the future . . . .

FIGURE 1 shows the layout of the electrical equipment used for induction heating at Latrobe Steel Co. It also shows the layout of the 10-in. mills, and material flow. In the upper right hand corner one can see that the 25-kv plant transmission voltage is stepped down to 4600 volts. From this substation, electric power at 4600 v is fed to the starters for the motors which drive the high frequency generators. The drive motors are rated 900 hp, 4600 v, 1800 rpm, 0.8 power factor synchronous. The generators are rated 600 kva, 800 volts, single-phase 3060 cycles. The power from the generators is carried to heating furnaces by two 750 MCM, coaxial cables. The power is transmitted approximately 1000 feet. The generators can be operated in parallel, but are being operated as independent units. If they were operated in parallel, some of the flexibility of heating would be lost.

The bars are fed from the loading station through the induction furnace and then to the mill. If coils are being rolled, the bars are first broken down in the

Figure 1 — Layout of 10-12-in. mills at Latrobe Steel Co. and induction heating units.


LOADING STATION
CONTROL STATION
INDUCTION
FCE #1
INDUCTION
FCE #2
2-750 MCM CABLES COAXIAL
2-750 MCM CABLES COAXIAL
MATERIAL FLOW
BAR
COIL
10-12" COMBINATION MILL
10" COIL MILL
COILER
TRANSF. 25 KV./ 4600 V. 3000 KVA.
MAIN CKT. BKR. 10-12" MILL
MAIN CKT. BKR 9" MILL
MTR #1 BKR. 10-12" MILL
MTR #2 BKR. 10-12" MILL
MTR #3 BKR. 9" MILL
MTR #4 BKR. 9" MILL
MOTOR #1 900 HP. 4600 V. 1800 RPM
MOTOR #2 900 HP. 4600 V. 1800 RPM.
MOTOR #3 900 HP. 4600 V. 1800 RPM
MOTOR #4 900 HP. 4600 V. 1800 RPM.
GEN. #1 600 KVA. 800 V. 1Φ 3060 CY.
GEN. #2 600 KVA. 800 V. 1Φ 3060 CY.
GEN. #3 600 KVA 800 V 1Φ 3060 CY.
GEN. #4 600 KVA. 800 V. 1Φ 3060 CY.
SECONDARY BKR.
SECONDARY BKR.
SECONDARY BKR.
SECONDARY BKR.
TO 9" MILL

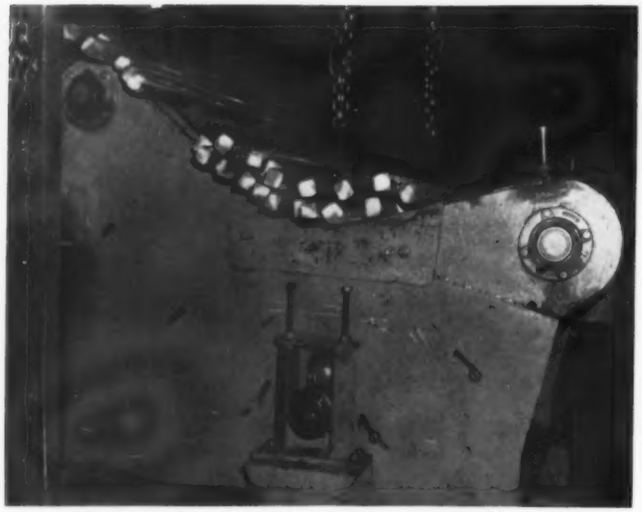


Figure 2 — Billet sorter has capacity of 6000 lb.

two 12-in. three-high stands. They are then fed to the 10-in. mill to be further reduced and coiled. When bars are being rolled, the conveyor is shifted to the first 10-in. three-high stand and multiple reductions taken.

The motor starting equipment for the motor-generator sets is conventional full-voltage starting equipment.

The synchronous drive motors are air-cooled, and the bearings are force lubricated. The oil is cooled by an oil to water heat exchanger.

Figure 3 — In normal operation billets alternate to the right and to the left.

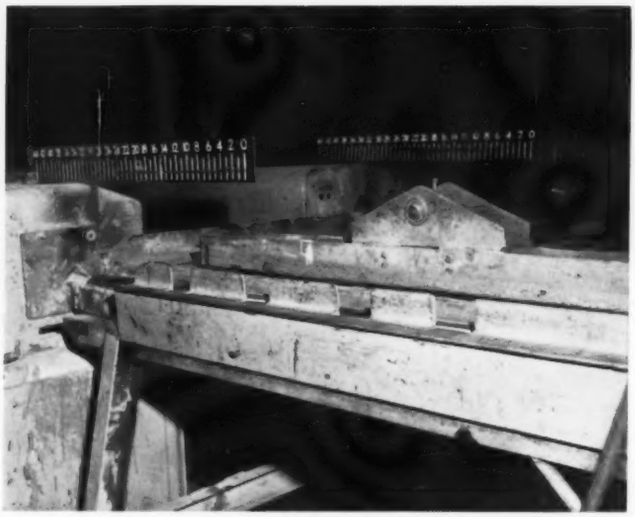


Figure 4 — Gages at charging end of furnace are used to position billets of different lengths.

The high-frequency generators are air- and water-cooled. The water cooling connections are in the lower part of the frame. The bearings are force lubricated the same as the drive motors. The generators are commonly called inductor generators.

The control panels for the high frequency generators are standard panels providing short-circuit protection and voltage regulation.

Each heating station has three line contactors. One contactor is for the preheat sections, and the other two are for the final heat section.The primary reason for using three contactors is to control the heating cycle. The billet, or billets, in the final heat section can be kept at temperature while the billet, or billets, in the preheat section are heating. Another reason for the three contactors is to be able to preheat a billet, or billets without a billet in the final heat section. By using this arrangement, the first billet from the heater is at rolling temperature.

In one section of the induction heating station are mounted capacitors and bus work.

Figure 2 shows the billet sorter. The sorter has a capacity of 6000 lb, and is electrically driven. The sorter can be controlled either manually or automatically by the operator. The sorter consists of an endless steel belt with angle clips welded on the belt. The angles are used to prevent the billets from sliding down the belt.

On the discharge end of the billet sorter is the line conveyor feeding the heating stations. The sorter discharges one billet at a time, either manually or automatically.

Figure 3 shows a billet on the positioning table. The billet is placed in either the right or left feed slot by the air cylinder and crosshead assembly seen on the left side. The air cylinder can be operated either manually or automatically as the billets are fed to the positioning table. In normal operations, the billets alternate to the right and left. After the billet is pushed into the feed slot, the hydraulic ram, seen in the rear of the slide, pushes the billet into the heating chamber. At the same time, a hot billet is ejected from the heating chamber.

Figure 4 shows the charging end of the two furnaces.

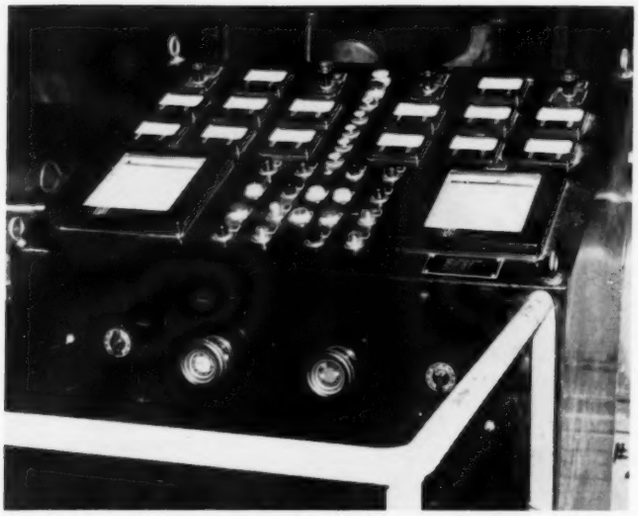


Figure 5 — The material handling and heating are controlled from control station.

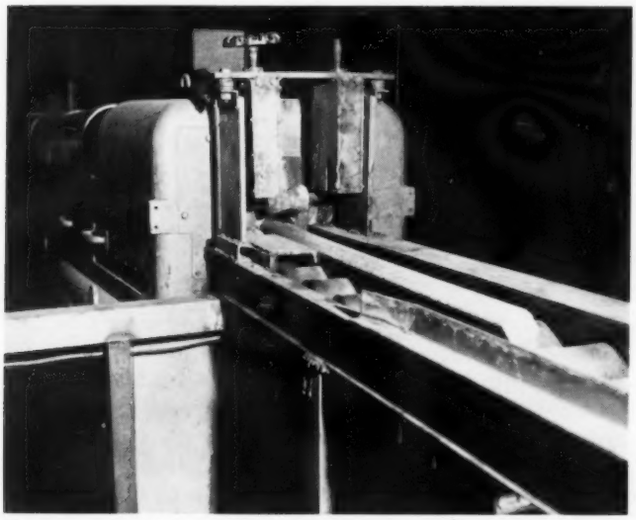


Figure 6 — Hot billet is being discharged from furnace.

The gages are used to position billets of different lengths.

Figure 5 shows a front view of the control station. All material handling and heating are controlled from this point by the operator. The cycle for a 2½-in. RCS x 76-in. long billet is three minutes. Four 120-lb billets are being heated simultaneously, two in each furnace. This means a billet can be fed to the mill every forty-five seconds. The operator has complete control of the heating cycle, and sets his heating rate to match the mill rolling rate. The final heat cycle of each billet is recorded by the use of radiation pyrometer and recorders. An alarm indicates to the operator when the billet is at temperature.

On the discharge end of the furnaces are mirrors used by the operator to observe the billet during the heat cycle. The billets are discharged, turned 90 degrees by the conveyor table, and discharged at the mill.

Figure 6 shows a hot billet being discharged from the furnace. The top pinch roll feeds the hot billet onto the line conveyor. The pinch roll tension is adjusted by the wheel at the top of the furnace. The over-all length of the induction coil is 14 ft. The maximum size billet that can be heated in this coil is 2¾ in. RCS. The coil is manufactured in four sections.

Figure 7 shows a close-up of the coil. This particular coil has recently been relined with new refractory.

Figure 8 shows a detail of the winding and assembly procedure. The coil is wound and assembled as follows:

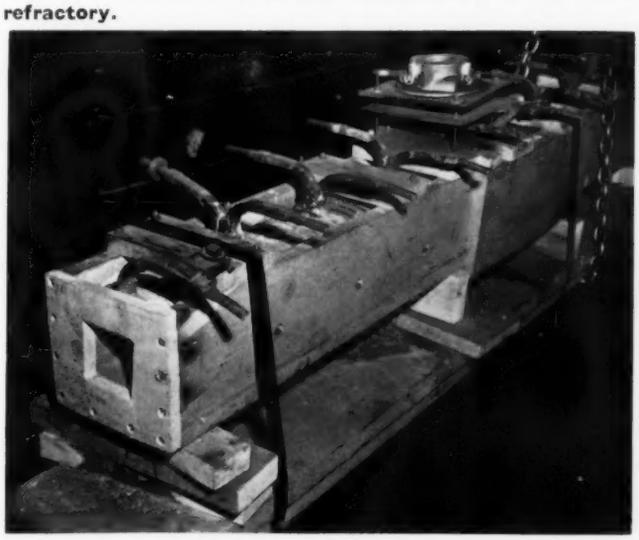
1. A steel mandrel is used to wind the coil on. The mandrel is greased with DC No. 3 silicon grease.
2. Next, seven layers of silicon cloth are wound on the mandrel under tension.
3. The silicon cloth is then taped with 1½-in. glass tape.
4. This assembly is then impregnated with silicon adhesive and baked.
5. The rectangular tubing is then taped with glass tape and wound on the mandrel assembly.
6. The entire assembly is then vacuum impregnated in silicon varnish and baked.
7. Four sections are then assembled into a coil.

The following discussion will cover some of the operating features of this equipment. There are, at the present time, two rolling mills using the induction method of heating. One is a 9-in. bar mill, and the other is a combination 10-in. coil and bar mill. Only the 10-in. mill installation, will be discussed as the 9-in. mill is very similar.

The 10-in. mill unit has a heating capacity of 9000 lb per hr. The billets heated at this mill range in size from 1½-in. RCS to 2¾-in. RC. The billet length varies from 24 to 76 in. Some of the grades which we are now induction heating are:

1. TNW (M-10)
2. Olympic (D-2)
3. Dynavan XL (T-15)
4. Double Six XL (M-2)
5. Corsair (M-3 Type 1)
6. Crusader (M-3 Type 2)
7. Viscount (H-13)
8. LPD (H-12)
9. Tatmo (M-1)
10. Lescalloy (Stainless)
11. Badger (0-1)
12. Hy-Chrome (AMS 5616)
13. E-1 XL (T-1)
14. GSN FM (D-3)
15. MGR (Chrome Base)

Figure 7 — This induction coil has been relined with new refractory.



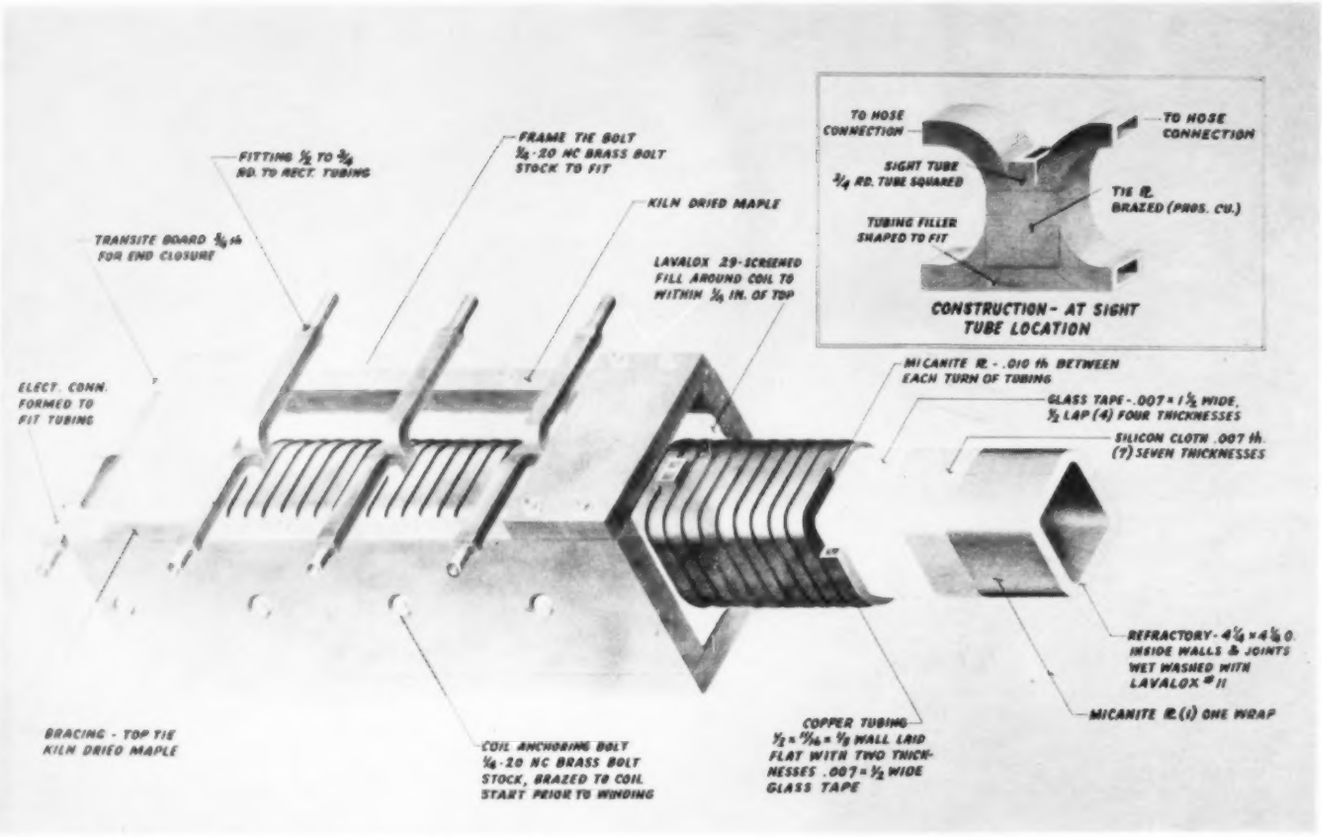

TO HOSE CONNECTION
TO HOSE CONNECTION
SIGHT TUBE 3/4 RD. TUBE SQUARED
TIE RD. BRAZED (PROS. CU.)
TUBING FILLER SHAPED TO FIT
CONSTRUCTION - AT SIGHT TUBE LOCATION
FITTING 1/2 TO 3/4 RD. TO RECT. TUBING
FRAME TIE BOLT 1/4-20 NC BRASS BOLT STOCK TO FIT
KILN DRIED MAPLE
TRANSITE BOARD 1/8 th FOR END CLOSURE
LAVALOX 29-SCREENED FILL AROUND COIL TO WITHIN 1/8 IN. OF TOP
MICANITE RD. - .010 th BETWEEN EACH TURN OF TUBING
ELECT. CONN. FORMED TO FIT TUBING
GLASS TAPE - .007 x 1 1/2 WIDE, 1/2 LAP (4) FOUR THICKNESSES
SILICON CLOTH .007 th. (7) SEVEN THICKNESSES
REFRACTORY - 4 1/4 x 4 1/8 O. INSIDE WALLS & JOINTS WET WASHED WITH LAVALOX # 11
MICANITE RD. (1) ONE WRAP
BRACING - TOP TIE KILN DRIED MAPLE
COIL ANCHORING BOLT 1/4-20 NC BRASS BOLT STOCK, BRAZED TO COIL START PRIOR TO WINDING
COPPER TUBING 1/2 x 7/16 x 1/8 WALL LAID FLAT WITH TWO THICKNESSES .007 x 1/2 WIDE GLASS TAPE

Figure 8 — Schematic shows details of coil assembly procedure.

16. Invar
17. Select B (A-2)
18. XL Chisel (S-1)
19. CO 12 (High Speed)

The kwhr per ton varies between 260 to 450. Some grades naturally require more kwhr to heat than others. The size and heating cycle also cause the power consumption per ton to vary. A good average figure per ton is 400 kwhr. This figure will include all losses from frequency conversion, transmission, and the heating unit.

Next maintenance costs for the induction heating equipment will be discussed. Maintenance has been a small item with this installation. We have not lost a coil in nearly two years of operation. Refractory life has also been excellent. Most of the refractory is lasting longer than twelve months. Routine maintenance is also minor. Once each week the heating coils are blown out with compressed air and swabbed with a wash coat of lavalox. Of course, routine maintenance is also required on the electrical equipment.

For the economics of induction heating, we will assume the cost of gas at 40¢ per million Btu, and electricity at 1¢ per kwhr or $2.92 per million Btu. This gives a ratio of 7.3 to 1 in favor of gas. Now if we assume a gas furnace efficiency of 30 per cent and an induction furnace efficiency of 70 per cent, this ratio is reduced to a factor of 3.1/1 in favor of gas. Converting these figures to a tonnage basis, we may be paying $4.00 per ton when heating by induction and $1.30 per ton when heating with gas. The difference in fuel cost is overcome many times when some of the following points are considered.

1. Consider scale loss on a per ton basis. Scale loss for gas heating is approximately 3 per cent. Scale loss for induction heating is under 1 per cent. Assuming a 2 per cent savings in scale loss, there is a savings of 40 lb per ton. Now, assuming a mill cost of the steel at this point of 23¢ per lb, there is a savings of $9.20 per ton. This item alone would come close to justifying the capital investment for the induction heating equipment.

2. Next, consider the decarburization of the outer surface of the steel during the heat cycle. Normally a considerable amount of billet conditioning is required to remove this decarb surface. This conditioning is done before rolling, after rolling, or both before and after rolling. If a decarb-free billet is fed to the induction heating unit, for all practical purposes, it is decarb-free after being heated. This item alone can account for several percent savings in billet and finished product conditioning.

Some of the other advantages of induction heating are:

1. Improved heating. The heat is developed entirely within the bar.
2. Increased production. The mill can be fed at a uniform rate.
3. Decrease rejects. Closer tolerances and better inspection at the mill when decarb and scale are not present.
4. Short start-up time when changing size, shapes and grades.
5. Eliminates holding large quantities of steel in furnaces.

In the future, it is expected that all of our mills will be using the induction method of heating. ▲

HIGH HEAD ALLOY SLAB HEATING for Planetary Mill Rolling

by OSCAR J. ZANATTA, Utilities Engineer, Atlas Steels Ltd., Welland, Ontario, Canada

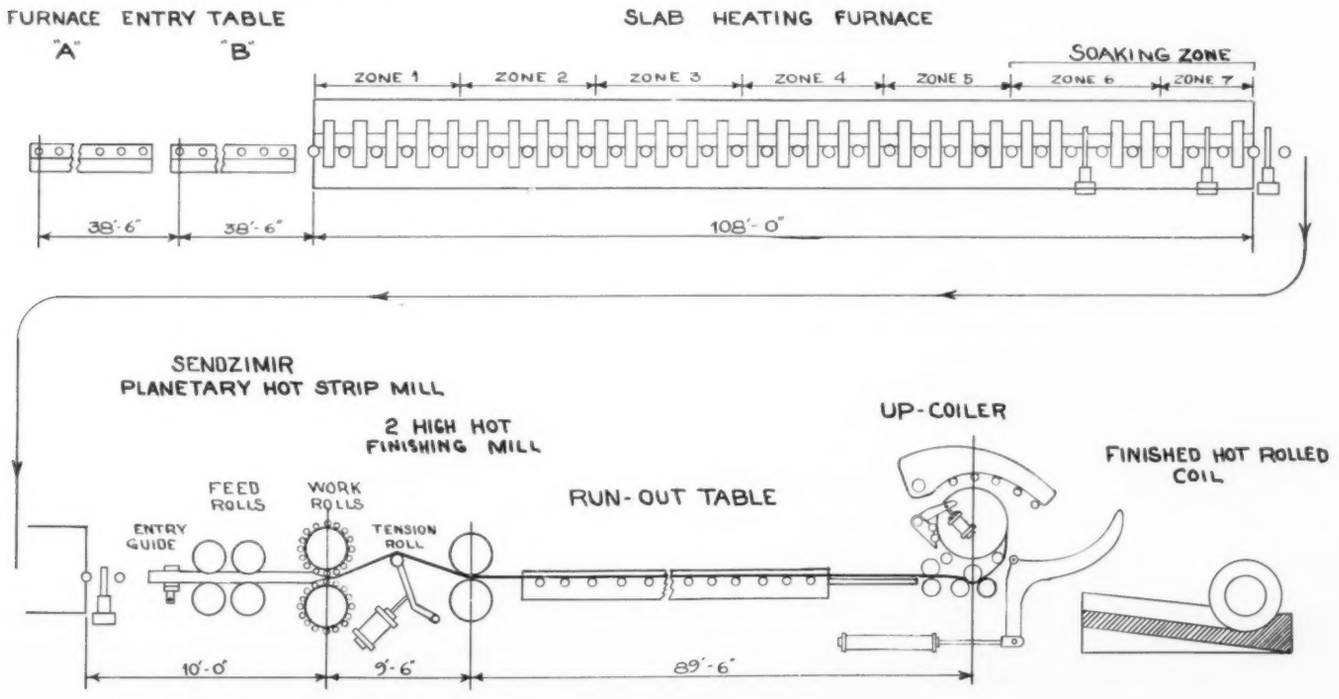
. . . . an inline furnace using the high-thermal-head principle gives rapid, scale-free heating of 25 to 30 tons per hr, with great flexibility . . . .

IN a highly competitive democratic society, the economic aspect of engineering most frequently dictates and molds the avenue over which the concentrated efforts of its members are directed. Old principles and ancient facts form the bases from which is developed new concepts. Progressive ideas and sometime idealistic thinking are reduced through the acidic and realistic climate of design to the most critical atmosphere of all, the practical and economically competitive ledger of everyday practice.

This paper will deal with one link in the chain which, when outstretched, forms the heating and rolling of alloy slabs by the use of a planetary-type rolling mill.

Figure 1 shows diagramatically the main components which comprise these hot rolling facilities at Atlas Steels Ltd. as they exist at present. The conditioned slab is fed by crane to the furnace entry table, then through the furnace on power driven rollers. The slabs have a maximum thickness of 2¼ by 20-in. wide, and a minimum length of 7 ft 6 in. and are heated by means of a high head, high velocity stream of tangentially directed bands of hot gas. The heat is transferred to the slab by means of high thermal radiation and convection of the rapidly moving gases

Figure 1—Hot rolling facilities at Atlas Steel include a planetary mill which produces 0.100-in. thick strip from a slab of $2\frac{3}{16}$ in. maximum thickness in one pass.



which are produced by the combustion of No. 2 fuel oil or natural gas. When the slab emerges from the furnace, it is forced into the planetary work rolls by two sets of feed rolls mounted in the same mill housing as the planetary assembly. To ensure an absolute uniform rate of feed into the main reduction unit, a total maximum reduction of $\frac{5}{16}$ in. is taken in the feed rolls. The remaining reduction to 0.100 in. in this one pass rolling operation, is made in the planetary work rolls. Due to the heavy reduction in the single set of work rolls comprising the planetary assembly, typical entry speed of 6 to 8 fpm is increased so that the strip from the 2 high mill and on the runout table travels to the upcoiler at a speed of approximately 100 fpm.

The specific aim of the author is to cover the design, construction, operation and maintenance of the unit which supplies hot, uniformly heated slabs for reduction to strip coil. The scope of the undertaking necessitates limiting the amount of minute detail to a very minimum.

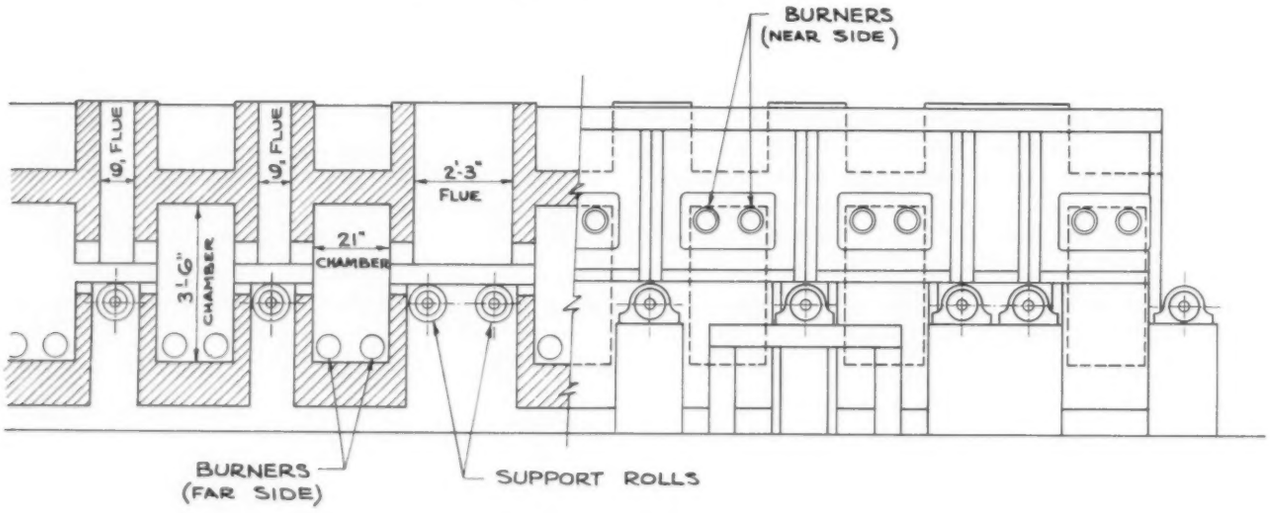
DESIGN

The decision to install a mill using planetary rolling to reduce alloy steel placed rigid demands on the type of heating unit which could be employed for this application. A uniformly heated, scale-free slab was necessary to ensure a quality product, with no danger of damage to the mill proper.

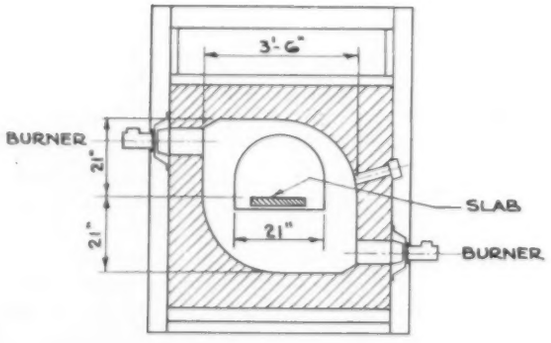
The design and operation of an atmosphere controlled furnace to heat steel at the rate of 25 to 30 tons per hr by conventional methods presented a formidable capital expenditure, and required much more space than could be allocated. It was, therefore, decided to employ the rapid heating, high-thermal-head principle using a series of small independent chambers. An estimate revealed that this would give a highly productive and flexible unit at approximately one-fifth of the cost of a rotary or a pusher furnace. The size of the furnace even in its present enlarged form, exclusive of control panels and piping, occupies a space only 8 ft wide by 180 ft long. The desirability of a small work force to operate the entire heating and rolling function was also a direct result of the design and method of operation of the system.

As indicated above, the furnace required a design which would give rapid, scale-free heating of 25 to 30 tons per hr of utmost flexibility to be located in a very restricted area. The furnace design which evolved on the drawing board was the result of many exhaustive tests; in the laboratory, in mock up models, and in actual field tests. The final physical appearance of the furnace and combustion chamber is extremely interesting because of its simplicity. A view of the com-

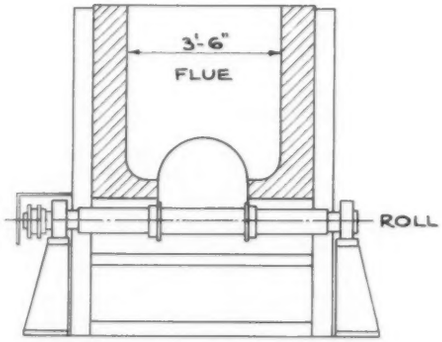
Figure 2—Sections show furnace details.



PART SECTION AT EXIT END OF FURNACE



TYPICAL SECTION
THRU COMBUSTION CHAMBER



TYPICAL SECTION
THRU ROLL CHAMBER & FLUE

bustion chamber section is shown in Figure 2. Note that the slab to be heated is very effectively surrounded by an extremely high velocity ring of hot gases. These are directed by the contour chamber design and the burner location, so as to transfer the thermal energy released to the work very efficiently by both radiation and convection. The tangentially-located burners fire into the cylindrically shaped combustion chamber between the chamber wall and the work.

The high-thermal-head heating technique utilized in this furnace is illustrated in Figure 3. This principle uses a fact which is known to occur during the initial portion of most heating cycles. The diagrammatic time-temperature heating curve indicates that the maximum rate of heat transfer occurs at the start of the heating cycle. This is apparent when comparing and analyzing the temperature curve of a conventional furnace. Another fact known to those who have studied thermodynamics, and recognized by heaters for many years is also clearly indicated in this illustration. Namely, the heat transfer rate progressively declines as the temperature of the steel increases, and to all practical purposes ceases when the work temperature reaches that of the furnace.

Therefore, it can be readily seen that if the furnace temperature is elevated to a level higher than the normal required rolling temperature (see curve Figure 3) then the fast rate of heat transfer obtained at the start of a conventional heating cycle is fully exploited. This is due to the high thermal difference existing between the relatively cold work and the hot furnace condition. Thus, the resultant steel heating curve is made much steeper, and the heating time proportionately reduced.

It has been proved by research and the theory, and proved in actual practice with this type of heating equipment, that the convection effects at elevated temperatures increases heat transfer rates as much as 20 per cent. Proper selection of burners and intelligent design of the combustion chamber is necessary to take full advantage of the forced convection effect. It follows that the increase in the heat transfer rate can be used in two ways; (1) to provide faster heating of the work in a given time, or alternately, (2) to permit a lower heating chamber temperature with the consequent decrease in over-all furnace maintenance.

The furnace combustion chamber is elliptical in cross section with an effective height of 3 ft 6 in., a width of 21 in. and a volume of 21.44 cu ft. Four burners of 1,500,000 Btu per hr rated capacity each fire into one chamber; two above the work and two below. In this way a rated thermal release per chamber of 6,000,000 Btu per hr or 279,000 Btu per cu ft is obtained. The hot products of combustion flue out through two ports in the end of the chamber and up through a 3 ft 6 in. by 9 in. flue located above the water-cooled work support rolls. Each flue is common to two chambers; that is, half the waste gases are exhausted through one end of a chamber by sharing the flue with an adjoining section. The burners themselves are of a dual-fuel type, although the furnace was originally equipped to fire only on oil. The wisdom of installing dual firing burner equipment has been proved in subsequent years since it has been the main source of obtaining and maintaining a very favorable natural gas

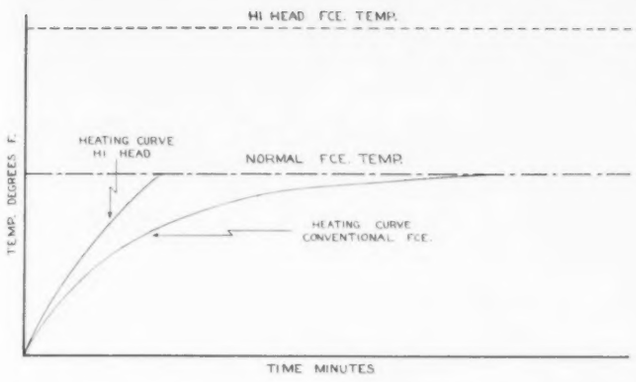


Figure 3—Curve illustrates the higher rate of heat transfer obtained in a high head furnace because of the wide difference between furnace and slab temperature.

contract. This furnace is used to maintain a constant load factor characteristic.

The individual chamber is an integral unit and independent from every other chamber, both from a structural and a refractory viewpoint. This concept facilitates repairs by creating a unit assembly consisting of sections which can be rapidly removed and replaced. Spare sections are always maintained in readiness for this purpose. A second important advantage is also gained by segmental construction. The very geometry of the chamber makes wall and roof repairs in such a confined space very difficult and costly. At best only a temporary patch can be obtained. It is much more advantageous from the standpoint of economy to simply remove the chamber, strip the old refractory from it, insert the proper forms and recast the chamber; the entire operation taking only a few hours. Figure 4 depicts an old chamber being removed from the furnace line. The old chamber is clearly illustrated in Figure 5. Figures 6 and 7 portray, respectively, a chamber after casting with the forms intact, and the same section after curing, ready to be reinserted into the combustion line. A third very obvious advantage to this construction is the absence of mill downtime required for repairs to the furnace. Although this is not a key factor for this particular installation, it could mean a very considerable savings and should not be overlooked.

A most important consideration in any furnace design is the refractory lining. This instance is no exception to the rule; rather, it becomes of prime importance due to the very severe thermal conditions under which the lining operates. Here again, one is surprised by the relatively simple design of the furnace interior. The steel chamber shell is first lined with 4½-in. course of 2600 F insulating fire brick. The inner lining is then cast around suitable forms to shape the elliptical chamber the end walls and one-half of the flue section. Burner and observation ports are also cast integrally at this time, making a monolithic structure possessing great strength. The furnace walls are only 9 in. in total thickness, yet the furnace operates consistently in the vicinity of 2650 F. It has been found that the furnace shell is relatively cold, and excessive heat loss is not experienced through the refractory. Therefore, it can be concluded that the refractory design is sound resulting in economy of original outlay, repairs and operating costs. The entire unit can be started from cold and be ready to operate in less than one and a half

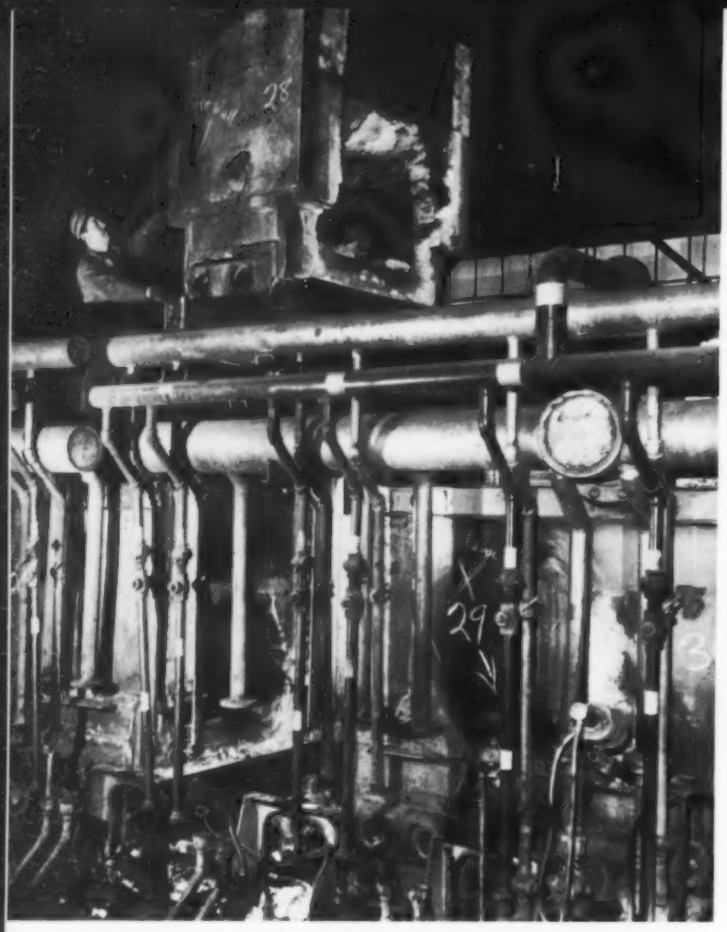


Figure 4—Ease of removal of an individual chamber is an important economic factor.

Figure 5—Old chamber shows the effect of slab abrasion and the high firing rate.

hours. When it is realized that the line has a total of 120 burners to be ignited, this is truly a remarkable performance. Refractory is to a great extent a key factor in making this possible, because the mass of refractory to be brought to temperature is relatively small, the monolithic cast lining is of such a design and quality to permit drastic thermal change and the method of heating itself is by convection and radiation from the hot products of combustion. This requires only the "skin" temperature of the lining to be at temperature.

Between each section or chamber spaced at 42 in. centers are located water-cooled rolls over which the slab is transported through the furnace during heating. Separating sections No. 26 and 27 and No. 29 and 30, there are placed two rolls in an enlarged flue section. These accommodate vertical water-cooled slab guides which properly aline the heated slab just prior to entering the planetary mill. The present design of roll is 7 in. OD x ½ in. thick wall by 5 ft 6 in. long cold drawn seamless steel tubing. Machined steel necks inserted at each end are carried by anti-friction bearings mounted on a fabricated steel pedestal, independent of the furnace shell. The independent mounting of the bearings and pedestals from the furnace insures continual and proper alinement of the roller conveyor sections, and is an important factor contributing to the ease and speed with which the chamber can be changed during maintenance operations. Each roll is individually cooled by an axial supply pipe. Nine gpm of untreated water is supplied to each roll at a pressure of 30 psig. This maintains the roll surface temperature below 1000 F. A simple forged flange of type 310 stainless steel, fitted loosely on the roll and held in place longitudinally by means of beads of weld on the roll at either side of the flange, prevent the slabs from contacting the furnace walls and causing damage to the refractory lining.

The rolls are driven by a sprocket roller chain arrangement through a 203 to 1 reduction gear. Three separate drives powered by 5 hp, 230 volt d-c motors are provided for maximum flexibility of speed control in the furnace. One drive and table section encompasses 11 furnace rolls at the entry side, No. 2 drive propels the 12 furnace rolls comprising the center of the table, and No. 3 system includes a ten-roll section at the exit end of the furnace. The speed control is obtained by d-c current change through a rheostat supplied by a shop motor-generator set to the field of the roller drive motors. (See Figure 8.) Forward roll speeds can be varied from 0 to 11.5 fpm, while reverse speeds can be varied from 0 to 29.2 fpm. This is necessary to eject the alloy slab from the furnace as quickly as possible when a delay is encountered at the planetary mill. The rapid removal of the steel is mandatory to prevent overheating and scale formation. This brings out another significant advantage of the high head heating unit. The relatively small charge in the furnace gives an added area of desired flexibility not found in conventional furnaces using the more standard accepted methods of heating.

In the preceding portion of the text, major individual sections of the furnace have been described as complete units and detailed as such. The reason for this procedure becomes quite obvious if Tables I and II are compared.

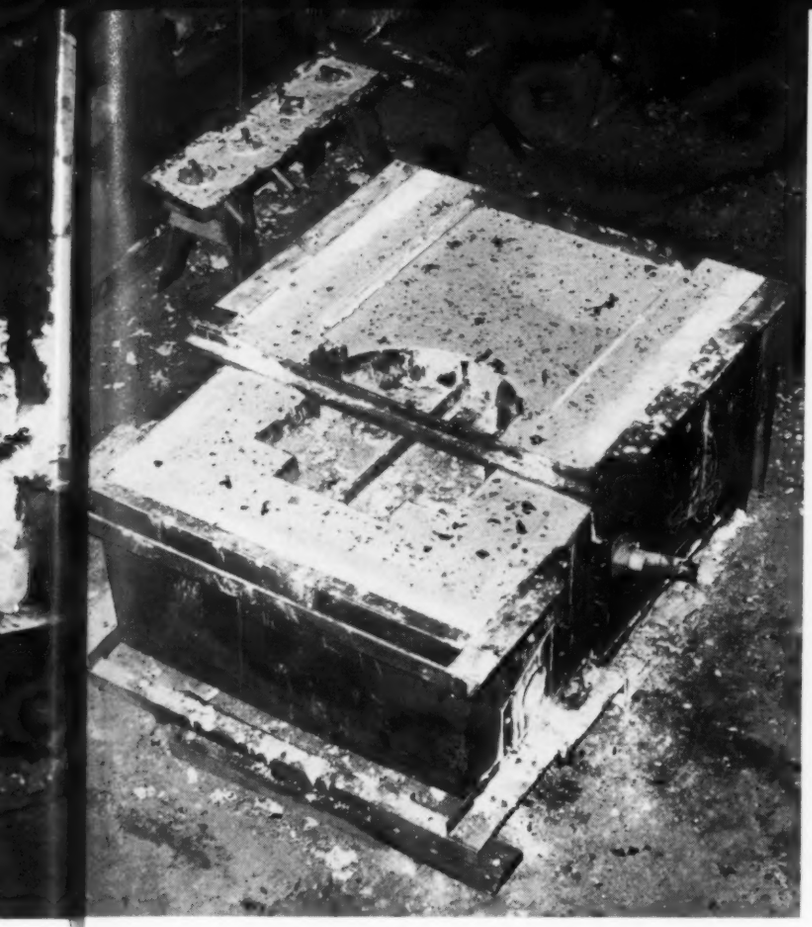


Figure 6—Casting of the monolithic refractory is a simple process and yields a structure with great strength.

Figure 7—End sills are constructed of a high duty shock resistance tile to withstand slab abrasion.

It will be seen that a great deal of change has taken place since the furnace was first installed. The basic units, chambers, drives, etc., have remained as the original, but two more zones consisting of a total of ten chambers were added in 1957. Also, during this period of furnace expansion and redesign, natural gas was added as the second fuel. The need for more accurate control was proved by actual operating experience and necessitated drastic changes to the entire fuel-air control system.

The furnace length was increased from approximately 74¼ ft to about 108 ft over all, and the zones from five to seven; burners were increased from 80 to 120, thus giving an additional 50 per cent more burner capacity. Actual field checks indicate that on 400 series stainless, a 2¼ in. thick slab 20 in. wide can be heated to a temperature of 2200 F in 15½ min, or at a rate of 1-in. of thickness in 6.88 min. If the hearth area of this furnace can be considered to be the product of the length of the furnace chambers, times the width of the section, the total effective hearth area would be 181 sq ft. At a normal output of 30 tons per hr, the resultant weight per sq ft of hearth per hr is approximately 330 lb. A comparison with conventional furnaces heating similar grades of steel will disclose an output of 50 to 75 pounds per sq ft of hearth area per hr.

The control function for a unit of high thermal release applied to rapid heating of alloy slabs is by necessity very precise and exacting. In the original design concept it was felt that maximum rate of heating would occur throughout the first three zones, with the remaining two zones used primarily for soaking. Consequently, it was felt that accurate fuel-air ratio should be maintained in these areas. The original furnace was designed to use oil as the fuel, although as previously mentioned, dual-fuel burners were specified. The decision to do so proved profitable when the second source of fuel (natural gas) became available. It may be pointed out that the burners handle both fuels with equal ease and with the same good heating results. It would be impossible from actual tests conducted during operations to give preference to either fuel. The selection of the heating media is influenced solely by economics, availability and convenience of use.

It was apparent from the very start of operations that the first three zones, contrary to previous expectations, would not be firing on a wide open basis and were capable of maintaining the temperature desired even at a full production rate. The need for metered fuel-air ratio control was evident. Therefore, this was installed on the remaining three zones during the addition of gas firing to the furnace. When two additional zones were installed, the same control pattern was extended to this part of the furnace. Primary temperature indication is obtained by sighting a thermopile arrangement on a closed end silicon carbide tube (Figure 9). The millivolt signal thus obtained is transmitted to a standard electronic servo-potentiometer with a range of 1200 to 2900 F. Primary control from the temperature instrument is by pneumatic impulse to an air motor driving an adjustable port valve in the combustion air supply. Fuel-air ratio on gas firing is maintained through a standard orifice metering

TABLE I
Technical Data, High Head in Line Furnace, Original Furnace Completed May, 1954

Zone	No. of chambers	No. of burners	Rated fuel input per hr. in millions of Btu	Fan capacity, cfm	Fan pressure, oz	Fan hp, 440 volt, 60-cycle, 3-phase	Fuel oil control	Air control	Temperature indication	Instrument range, F	No. of rolls	Roll cooling water, gphr	Roll seal water, gphr	Length of zone, ft	Roll drive sections, 203 to 1, reduction, 5 hp, 230-volt, d-c motor, 250 volt, d-c generator
1	5	20 400-psi recirculating system No. 2 oil	30	5000	24	50	¾-in. adjustable port in tandem valve	Pneumatic with 14-in. adjustable port, reverse opening to oil valve	Electronic	1200 2900	5	2700	Nil	17.4	12 Rolls
2	5	20 No. 2 oil	30	5000	24	50	¾-in. adjustable port in tandem	Pneumatic with 14-in. adjustable port	Electronic	1200 2900	5	2700	Nil	17.4	
3	4	16 No. 2 oil	24	5000	24	50	¾-in. adjustable port in tandem	Pneumatic with 12-in. adjustable port	Electronic	1200 2900	5	2700	Nil	14	
4	4	16 No. 2 oil	24	4000	24	40	¾-in. adjustable port, pneumatic	Hydraulic 12-in. butterfly	Electronic	1200 2900	4	2700	Nil	15.4	11 Rolls
5	2	8 No. 2 oil	12	2000	24	25	¾-in. port, pneumatic	Hydraulic 8-in. butterfly	Electronic	1200 2900	4	2700	Nil	8	

system located in the gas and air lines, operating through a hydraulic proportioning relay to control the adjustable port valve in the gas line. The control system is basically the same for oil. Oil flow is balanced against air flow by means of a pneumatic impulse generated by, and proportional to, oil flow acting through the same hydraulic proportioning controller that actuates the gas cylinder. In this case, however, the oil control valve is operated through a second independent hydraulic cylinder as illustrated in Figure 10.

To insure maximum flexibility and rapid changeover from one fuel to another, as may be demanded by emergency circumstances or the unavailability of natural gas, the same basic controller is used for both fuels. Thus, considerable expense was eliminated by making the purchase of dual controls unnecessary. The latter is made possible through a unique switching arrangement which permits changing the impulse lines from the gas orifice to the signal line from the oil hydraulic-pneumatic device. At the same time the hydraulic power lines from the fuel ratio controller are transferred from one fuel control valve operator to the other. Another switching arrangement changes the electrical control auxiliaries to correspond with the fuel being used (Figure 11). Clean air is supplied to the control by means of a small air compressor adjoining the panel, while the plant air supply is interlocked to the system as a source of emergency and standby supply.

The safety of operating personnel and the prevention of damage to equipment are of primary importance and the furnace has been equipped with protective devices

Figure 8—Roll speeds can be varied from 11.5 fpm forward to 29.2 fpm in reverse.

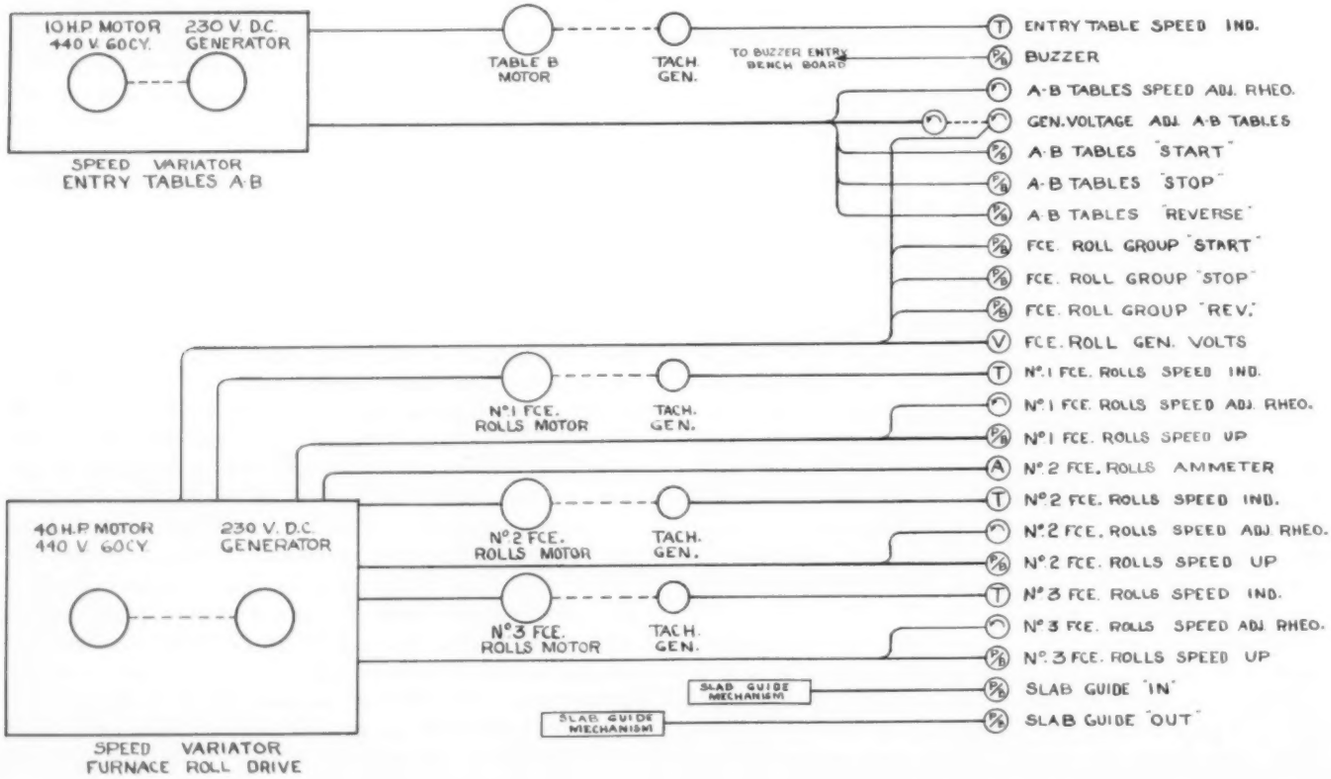

10 H.P. MOTOR 440 V. 60CY.
230 V. D.C. GENERATOR
SPEED VARIATOR ENTRY TABLES A-B
TABLE B MOTOR
TACH. GEN.
TO BUZZER ENTRY BENCH BOARD
ENTRY TABLE SPEED IND.
BUZZER
A-B TABLES SPEED ADJ. RHEO.
GEN. VOLTAGE ADJ. A-B TABLES
A-B TABLES "START"
A-B TABLES "STOP"
A-B TABLES "REVERSE"
FCE. ROLL GROUP "START"
FCE. ROLL GROUP "STOP"
FCE. ROLL GROUP "REV."
FCE. ROLL GEN. VOLTS
N°1 FCE. ROLLS MOTOR
TACH. GEN.
N°1 FCE. ROLLS SPEED IND.
N°1 FCE. ROLLS SPEED ADJ. RHEO.
N°1 FCE. ROLLS SPEED UP
N°2 FCE. ROLLS AMMETER
N°2 FCE. ROLLS SPEED IND.
40 H.P. MOTOR 440 V. 60CY.
230 V. D.C. GENERATOR
N°2 FCE. ROLLS MOTOR
TACH. GEN.
N°2 FCE. ROLLS SPEED ADJ. RHEO.
N°2 FCE. ROLLS SPEED UP
N°3 FCE. ROLLS SPEED IND.
N°3 FCE. ROLLS MOTOR
TACH. GEN.
N°3 FCE. ROLLS SPEED ADJ. RHEO.
N°3 FCE. ROLLS SPEED UP
SLAB GUIDE MECHANISM
SLAB GUIDE "IN"
SLAB GUIDE MECHANISM
SLAB GUIDE "OUT"
SPEED VARIATOR FURNACE ROLL DRIVE

TABLE II

Technical Data, High Head in Line Furnace, Present Furnace Completed June, 1957

Zone	No. of chambers	No. of burners	Rated fuel input per hr in millions of Btu	Fan capacity, cfm	Fan pressure, oz	Fan hp, 440-volt, 60 cycle, 3-phase	Fuel oil control, adjustable port pneumatic hydraulic	Temperature indication	Gas control, adjustable port hydraulic	Air control, adjustable port pneumatic	Instrument range, F	No. of rolls	Roll cooling water, gphr	Roll seal water, gphr	Length of zone, ft	Roll drive sections, 203 to 1 reduction, 5 hp, 230-volt, d-c motor, 250-volt, d-c generator
1	5	20 No 2 oil, natural gas	30	5000	24	50	¾-in.	Electronic	6-in.	14-in.	1200 2900	5	2700	1440	17.4	
2	5	20 No. 2 oil, natural gas	30	5000	24	50	¾-in.	Electronic	6-in.	14-in.	1200 2900	5	2700	1440	17.4	11 Rolls
3	5	20 No. 2 oil, natural gas	30	5000	24	50	¾-in.	Electronic	6-in.	14-in.	1200 2900	5	2700	1440	17.4	
4	5	20 No. 2 oil, natural gas	30	5000	24	50	¾-in.	Electronic	6-in.	14-in.	1200 2900	5	2700	1440	17.4	12 rolls
5	4	16 No. 2 oil, natural gas	24	5000	24	50	¾-in.	Electronic	6-in.	12-in.	1200 2900	5	2700	1440	14	
6	4	16 natural gas	24	4000	24	40	¾-in.	Electronic	6-in	12-in.	1200 2900	4	2160	1050	15.4	10 rolls
7	2	8 No. 2 oil natural gas	12	2000	24	40	¾-in.	Electronic	4-in.	8-in.	1200 2900	4	2160	1050	8	

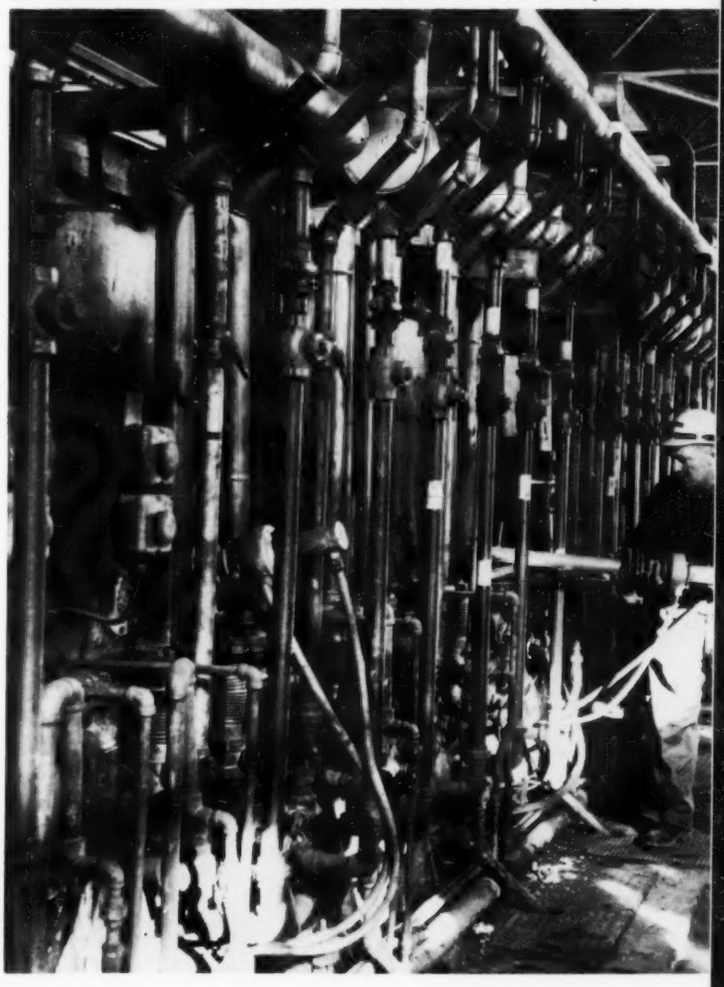
to provide both. Each zone has been designed to operate separately from the other. In essence, there are seven distinct furnaces in this line, each possessing its own autonomy as far as control, fans, gas and oil supply, pressure regulation and safety devices are concerned.

The only interlock functions common to all zones are master pressure switches located in the instrument control air supply, and contactors in the motor room ventilation system. Control air must be above 25 psig, and the motor room exhausters running before any other circuits are permitted to operate. When failure takes place in any of the control functions, the fuel supply is cut off to that zone by means of an approved safety shut-off valve located in the gas and oil lines. An alarm is then sounded and the zone giving trouble is indicated on the control panel by an amber light. To protect the charge during emergencies such as this, the temperature controller is by-passed and full control air pressure used to open the combustion air adjustable port valves.

The furnace is also protected against failure of combustion air or power to the fan by means of a low pressure limit switch located at the discharge of each combustion blower. Oil and gas pressure failure is monitored through pressure sensing devices in the lines of the respective fuels and functions in connection with the safety shut-off valves. High gas pressure resulting from a defective gas pressure reducing valve would rupture the fuel-air ratio diaphragm. To prevent this from happening, a high pressure limit is located in the gas line. A fusible link arrangement in the head of the thermopile assembly protects the device from damage by flame impingement if the silicon carbide sighting tube is fractured. When a unit of such high thermal release is operated at elevated temperatures, an unwanted temperature rise of even a small amount above the set point would cause damage to the refractory lining and could overheat the steel. A precaution used to prevent this condition is constructed into the instrument in the form of a high limit cut-out switch. Figure 11 depicts schematically, the electrical interlocks which combine to form the safety control system just outlined.

All piping to the furnace, including the feeders from the air blowers, has been sectionalized to facilitate rapid and easy removal of the individual chambers for maintenance replacement. The original concept specifying the use of a light gage sheet metal fabricated conduit for the combustion air was abandoned in favor of a standard schedule 40 pipe. The decision to do so has proved sound from the standpoint of durability. Light gage pipe would never have withstood the usage to which the equipment has been subjected. All connections at the burners are made through flexible

Figure 9—Furnace temperature is determined through the use of a closed end silicon carbide tube and a thermopile.



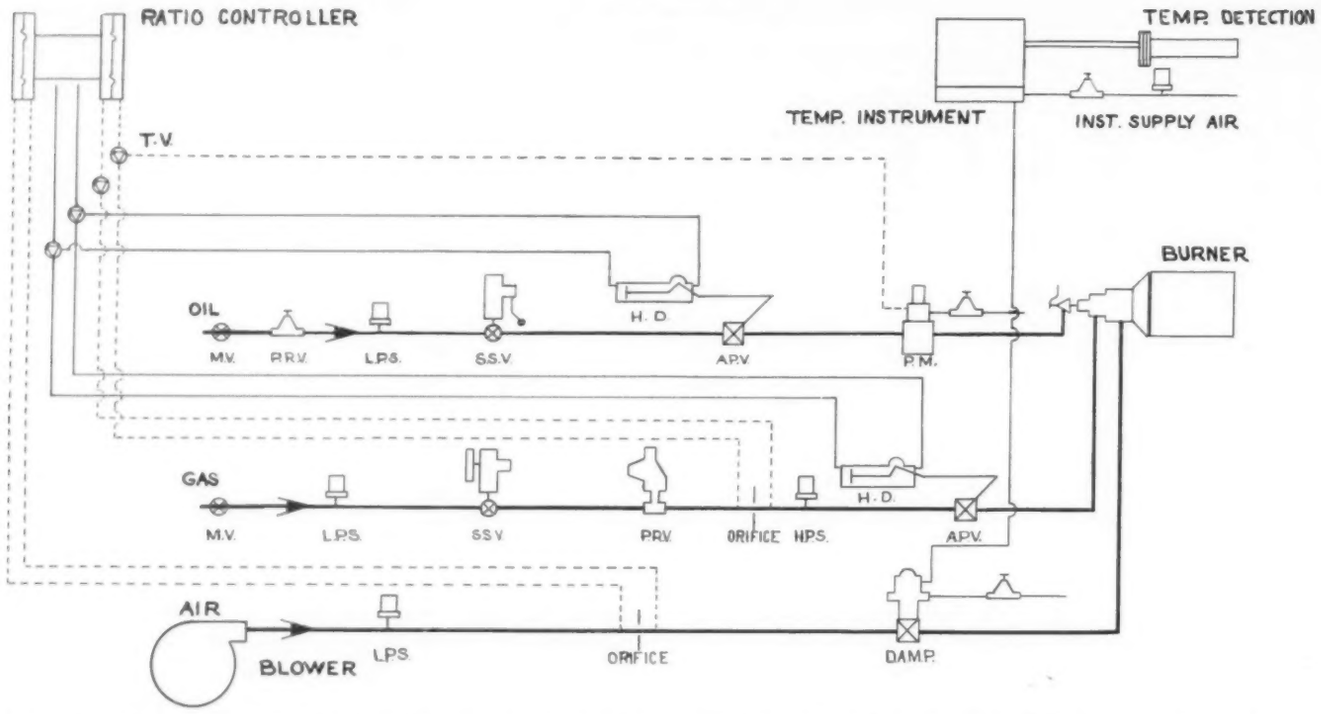


Figure 10—A dual fuel system permitting use of the same basic controller for each fuel was installed to permit maximum flexibility.

metal pipe, a fact of utmost importance when replacing chambers after maintenance since perfect alinement of all the burners is impossible under such conditions.

Several schemes to make use of the heat available in the exhaust gases have been thoroughly investigated. To recover heat by means of a recuperator would require a production schedule of an eight hr day for 200 days per year to pay for itself in nine years. With only a fraction of this production presently realized, the venture was considered impractical. The furnace would also have to be started three hr before rolling to allow stable conditions to exist in the recuperator. During the heat-up time, it would be necessary to make manual burner adjustments continually to maintain the fuel-air ratio, or purchase a very expensive control system because of the constantly changing air density.

Consideration was likewise given to heat recovery by generation of steam in a waste heat boiler. This ap-

Figure 11—A switching arrangement changes electric control auxiliaries to suit fuel being used.

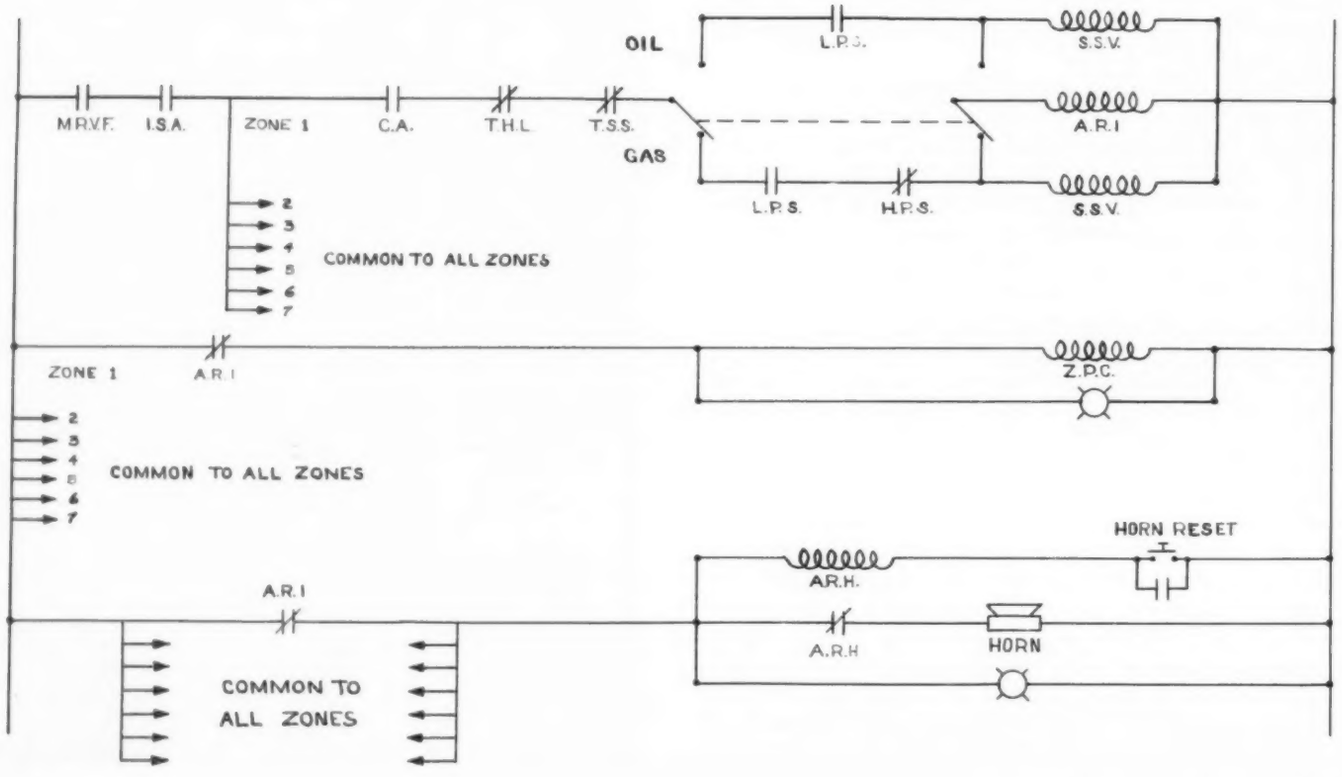


TABLE III
Glossary of Abbreviations
(Used in Figures 10 & 11)

A.P.V.	Adjustable port valve
A.R.	Auxiliary relay
A.R.H.	Auxiliary relay horn
C.A.	Cumbustion air
D.A.M.P.	Diaphragm air motor with positioner
H.D.	Hydraulic drive
H.P.S.	High pressure switch
I.S.A.	Instrument supply air
L.P.S.	Low pressure switch
M.R.V.F.	Motor room vent fan
M.V.	Main valve
P.M.	Pneumatic oil meter
P.R.V.	Pressure reducing valve
S.S.V.	Safety shut-off valve
T.H.L.	Temperature high limit
T.S.S.	Thermopile safety shutter
T.V.	Transfer valve
Z.P.C.	Zone protection coil

proach was deemed unsound because of the capital involved, the inability to locate the proposed boiler near to present steam generation equipment, and the relatively small length of time that waste heat would be available for steam generation.

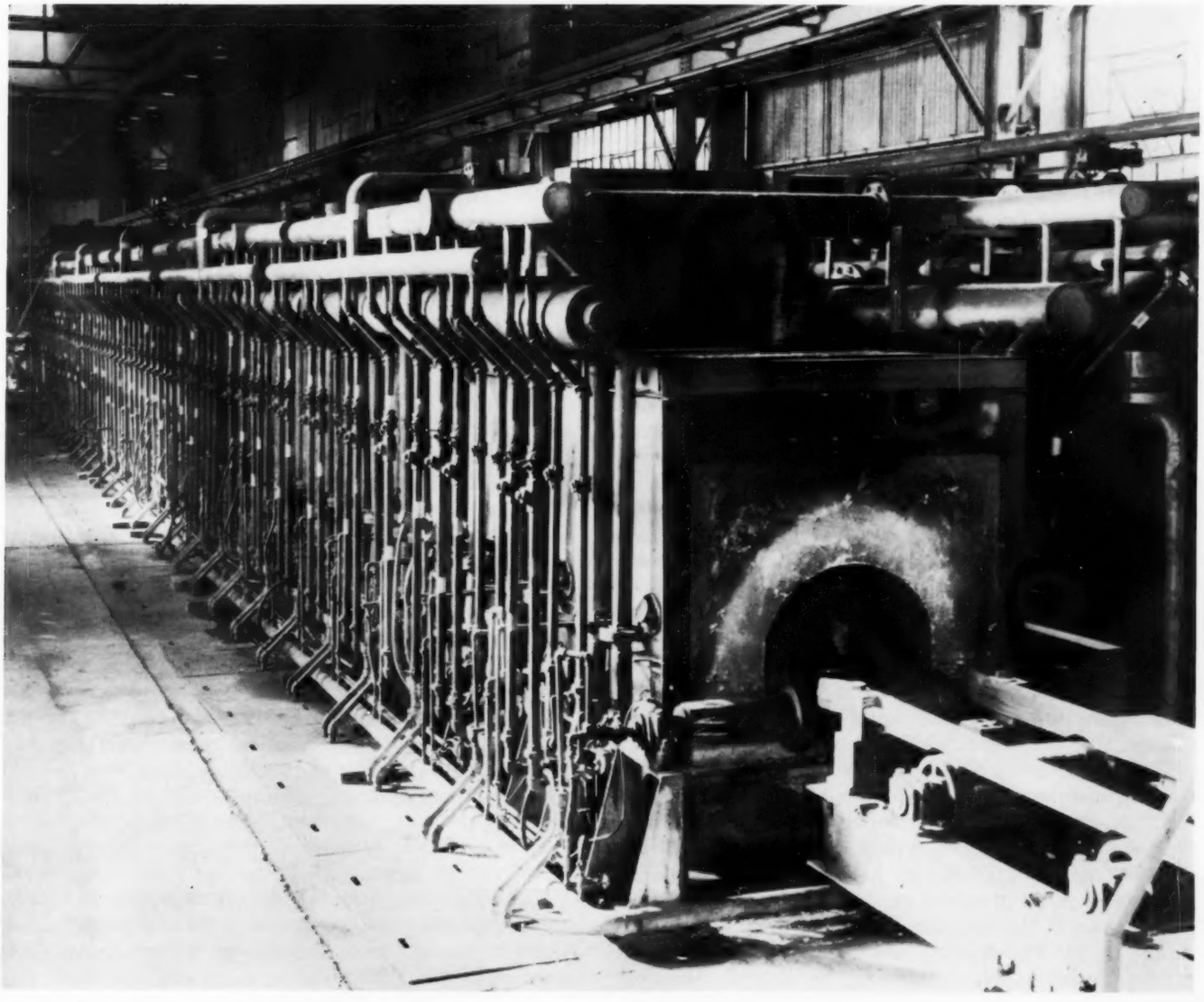
Many investigations were also conducted to determine the feasibility of using escaping hot products of combustion in preheating the steel prior to entry into the high head furnace. Consideration was given to a walking beam preheat furnace, two semi-continuous preheat furnaces, a drag chain preheat furnace and a cylindrical type preheating furnace similar to the installed unit in design. All the above ideas were abandoned either for economical reasons or design complications which would render them impractical.

CONSTRUCTION

Actual erection of the furnace was scheduled for the winter of 1953–54 which presented several definite problems. The building where equipment was to be installed was not heated, and being only partly closed in, the temperatures could be expected to average 15 to 25 F. It was, therefore, decided to cast and cure the individual chambers prior to shipment from the manufacturer. A great deal of discussion regarding precautions during transportation proved to be unwarranted. The chambers arrived in perfect condition; the normal vibration and shock of transportation had no effect on the cast refractory lining.

The foundation provided for an excavated portion at the discharge end to facilitate inspection and repair

Figure 12—Original installation of the furnace used only oil although dual fuel burners were installed.



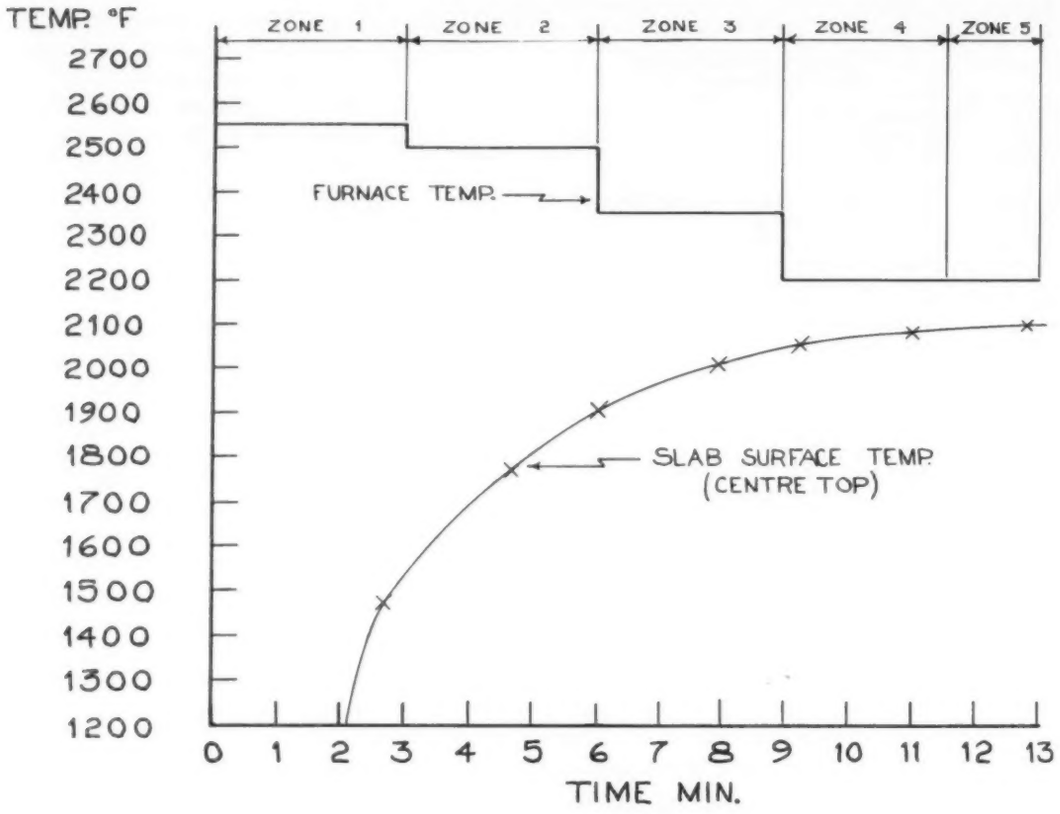


Figure 13—Heating cycle of furnace as originally installed.

to the vertical slab guides. Provisions were made adjacent to the furnace for a pump pit and tank to reclaim the cooling water from the rolls. The water reclaimed can be either recirculated to the rolls or fed to other units in the mill, depending on the water temperature.

Actual furnace erection was very rapid since most of the assembling was done before the chambers were transported to the erection site. The furnace rolls were placed on the pedestals and bolted to the foundation, alined and leveled. It was then relatively simple to lower the semi-piped, precast chambers into position, complete the precut piping, wire in the controls, fans and roll drives. The entire operation was comparable to a building block assembly. When the furnace had been completed and all the individual components tested, the entire unit was carefully dried to eliminate moisture absorbed into the refractory during transportation and storage prior to assembly.

The high head heating unit was completed well in advance of the mill which provided valuable time for field trials and necessary modifications. The unit was fully ready for operation with many of the adjustments and difficulties ironed out prior to the start of production. Figure 12 illustrates a general view of the furnace taken from the entry end, after the addition of gas piping.

It was evident the first time the furnace was brought to temperature that the velocity of the products of combustion would not all be directed up and out of the flues. Air was not being aspirated from the bottom of the chamber up past the roll as had been expected. The high velocity and pressures experienced in the chambers caused some of the hot gases to be directed down on the furnace rolls. The result was excessive heating to the exposed furnace shell and damage to the roll bearings. Immediate experimentation indicated that flue gas velocity was not uniform over the entire flue area. A redesign of the opening in the end wall of the furnace chamber tended to reduce this nonuniformity, but did not eliminate the condition sufficiently to prevent heat damage to the roll bearings. An insulating fire brick deflector baffle was tried in order to prevent the impingement of gases on the bearings. This was successful to a limited extent only, since the brick curtain protected the bearings, but the steel shell of the chambers was still exposed. It became evident after trying several other solutions that the rolls would have to be enclosed on the bottom by refractory, and at the sides by means of a water-cooled panel. This action exposed the roll proper to more heat and required more water for cooling. Larger slip joints were installed, but at this time any adverse effects from modifying the roll section of the furnace were not in evidence and could not be determined. Difficulties which developed from these design changes and the steps taken for correction will be detailed under a section devoted to furnace maintenance. Considering the complexity of design and the new principles involved, furnace construction and the initial stages of operation gave relatively little difficulty. When the problem of roll bearing shielding and furnace steel protection had been solved, it became merely a question of proper heating and operating procedures.

OPERATION

The operation of the furnace is comparatively simple, requiring only two people, a heater and a furnace charger. The names of the jobs are self-explanatory and need no further elaboration.

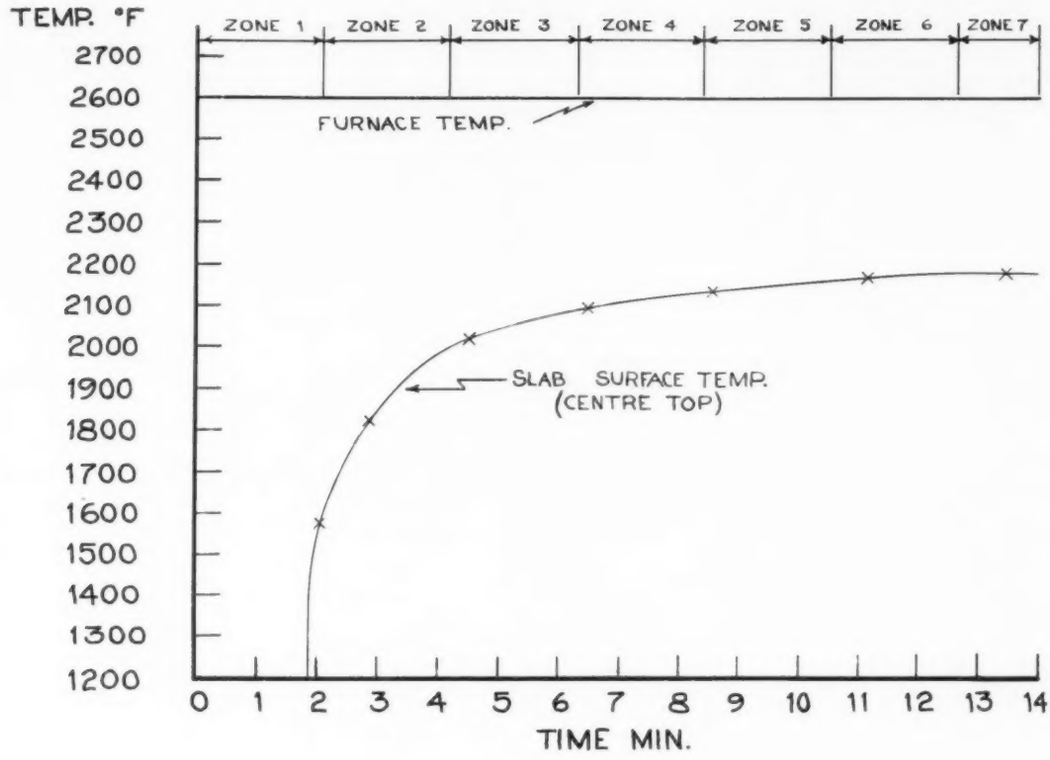


Figure 14—The modified furnace permits the use of the last four zones for achieving uniform slab temperature through their use as soaking zones.

The heater reports to work approximately one and a half hours prior to the beginning of the shift, at which time he proceeds to light up the furnaces. The unit is brought to operating temperature with ease in the time allotted. During the light-up period, and at all times while operating, the furnace rolls are kept in constant motion. This insures uniform temperature and warping of the roll is prevented. A goose-neck arrangement at the one end of the roll provides ample cooling water, and a visible discharge indicates whether or not water is flowing to the roll. A rigid check of this function is followed by the heater prior to every light-up period and also at frequent intervals during the rolling operation. It is the heater's responsibility to select a proper zone temperature combination so that the slab emerges at the desired temperature with a suitable soak. At his discretion he can speed up or slow down the furnace tables to achieve the desired results. He must, however, always bear in mind that all slabs must butt against one another at the exit of the furnace so that proper entry can be made into the planetary mill. Usually, when the temperature combinations have been established and the furnace and mill speed chosen, very little, if any change in the temperature setting is required.

The heater maintains a further check on the charge temperature by means of an optical pyrometer. The checks are only possible after the slab enters the enlarged section of the flue housing the slab guides. At this point a clear sighting is made on the steel without flame interference. It may be pointed out that very little heating is accomplished beyond these points because of the proximity to the furnace discharge. Only the final uniforming and soaking occur in the last four chambers. Consequently, the heater's selection of the proper furnace temperatures prior to charging is of prime importance. One final temperature check is made by an optical pyrometer as the slab exists from the furnace.

The unit is performing very satisfactorily under actual operating conditions, especially on 300 series stainless. Some difficulty is being experienced in uniforming the 400 series, but experimentation is continuing at present in an effort to correct this condition. The graph in Figures 13 and 14 indicate the heating cycle of the original five zone furnace as opposed to the heating as it takes place under present conditions. This curve is intended to be a typical curve and is to be considered only for illustrative purposes. Actual heating practice is varied to achieve certain desired characteristics in the mill. Edge checking and surface finish are two very important factors which depend directly on the heating procedure.

Furnace atmosphere is maintained as close to neutral as possible to obtain efficient heating and to keep free oxygen from forming scale during the high temperature heating of the slab. Scale is detrimental to the rolling operation and also to the furnace lining. Absorption of iron oxide into the castable can cause rapid failure of the refractory through spalling. Considering this inherent lack of scaling, the surface condition of steel fed to the furnace will bear directly on the hot-rolled product from the mill. No conditioning by scaling can be expected or is generated in this type of heating operation.

MAINTENANCE

More often than not, maintenance in many organ-

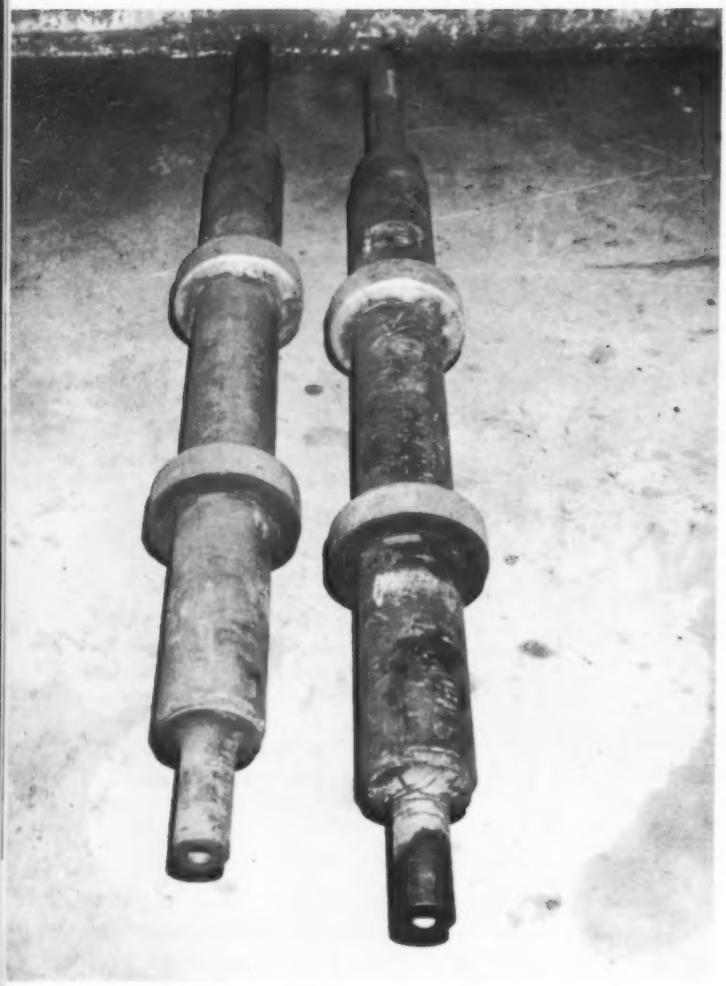


Figure 15—Mild steel rolls have performed satisfactorily in the 2600 F furnace operating temperature.

Figure 16—The original alloy rolls failed because of the high temperature differential between the contact area and the water passage.

izations has been considered an unnecessary expenditure, but it can be, and often is, a most important tool in the efficient operation, development and perfection of engineering designs. When the experience of maintaining and repairing equipment under actual operating conditions is subjected to proper engineering analytical methods, startling results can be forthcoming. This will be demonstrated in the following section.

Failures in a unit of this nature occur in two main categories; (1) control and combustion equipment, (2) refractory and equipment subjected to heat. The rapid technological development in the fields of electricity, electronics, pneumatics and hydraulics as applied to temperature control has infinitely improved the accuracy of temperature indication and the reliability of combustion control. Without these advances, it would be impossible to heat in this manner. The skill of the heater has to a large extent been replaced by the technical aptitude of the combustion technician. Much of the success of good heating during a rolling from this unit is accomplished well in advance of the actual lighting-up time by proper and skillful maintenance to the control and temperature functions. If failure should occur in any part of the combustion circuit, the very nature of the rapid heating cycle itself will lead to a forced cessation of the rolling operation. Therefore, prior to the lighting-up of the furnace, a thorough check up is made of all control equipment; combustion, electrical and pyrometrical.

The refractories, burners and water-cooled rolls are checked after each week's operation by an internal inspection of the furnace. Very few difficulties and little maintenance has been necessary with the burner equipment. During the entire five years of operation no burner has required replacement because of failure on oil or gas firing. Likewise, no difficulty has been experienced by the burner equipment in handling either of the fuels.

Problems encountered with the original alloy rolls have been minimized after a great deal of experimentation. All the rolls in the furnace have been replaced with a relatively inexpensive roll made from mild steel pipe. The comparatively poor thermal conductivity of alloy material in the original design caused a high temperature differential to exist between the outside surface in contact with the products of combustion, and the cool inside surface in contact with the cooling water. The resulting high stresses caused failure to the roll by means of longitudinal ruptures. The installation of mild steel rolls has greatly reduced this problem and materially reduced the maintenance costs. Figures 15 and 16 depict, respectively, new rolls contrasted with rolls which have failed in service.

The cast refractory lining has functioned very well under conditions of tremendous thermal shock existing

during the light-up and operating periods. During this time, the furnace is brought from cold to the operating temperature of 2600 F in approximately 45 min. Even under such severe operation very little thermal cracking is evidenced and no spalling has been experienced. The failure of the refractory in most instances is due to mechanical shock and wear, caused by the movement of the slab through the furnace. The "bent" slabs shear the cell sill exposing the support rolls to heat and thus weakening the entire end wall of the chamber. It is in this area that most refractory failure occurs. Very rarely is the actual hearth, walls or roof of a chamber badly damaged. To effect these repairs, the chamber is removed from the furnace as a unit (see Figure 4) and the old refractory broken out. Steelwork repairs are made when necessary before the forms are inserted for recasting. Following this, the chamber is stripped and cured in the repair area to the north of the furnace. Spare chambers are kept in readiness at all times to facilitate rapid exchange.

In an effort to minimize maintenance of these chambers, a co-ordinated program has been launched by the operations, maintenance and engineering departments concerned. A concentrated effort to minimize the number of warped slabs entering the furnace has materially reduced the damage to the sills. Several other items currently under experimentation show signs of promise in further reducing repair costs. These are listed as follows:

1. Casting the chambers using a super duty castable.
2. Constructing the end sill of each chamber from a high duty shock resistant tile anchored deeply between the castable and the steel shell.
3. Splitting of the chamber in a horizontal plane just above the lower set of burners. This will facilitate repairs without necessitating removal of the entire chamber burners, pipes, rolls and auxiliary equipment.

SUMMARY

In conclusion, the progress made at Atlas Steels Ltd. with this type of heating clearly indicates the advantages of the high thermal head principle. These can be summarized as:

1. The use of elevated furnace temperatures for the heating of alloy steels is practical for planetary mill operation.
2. High thermal head heating will give the required scale-free product for rolling in a planetary type hot mill.
3. Special and complex heating equipment is not necessary to obtain high thermal release in a chamber.
4. A high head in-line furnace provides a unit of extreme flexibility.
5. Periodic operation of the furnace allows the unit to be conveniently emptied and shut down, saving both fuel and labor.
6. Repairs can be made with little or no shutdown of the production unit.

Discussion

PRESENTED BY

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OSCAR J. ZANATTA, Utilities Engineer, Atlas Steels Ltd., Welland, Ontario, Canada

W. M. BLOOM, Senior Engineer—Fuel, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

I. D. AKEY, Superintendent, Combustion Dept., Great Lakes Steel Corp., Div. of National Steel Corp., Ecorse, Detroit, Mich.

G. D. COBAUGH, Specialty Sales Manager, Harbison-Walker Refractories Co., Pittsburgh, Pa.

J. E. HOVIS, District Manager, Bloom Engineering Co. Inc., Cleveland, Ohio

R. G. Graham: There is one thing which was not stressed enough; that is, the flexibility of the heating. In a mill such as at Atlas, you have many small orders. Say you are running 300 series and you wish to run one slab of a 400 series steel. You simply reset your mill speeds as soon as the furnace is empty, and perhaps your control temperatures, run the one slab for the order and go right back to the 300 series production. This is an advantage to people operating bar and slab furnaces.

Another thing that seems to be coming is the demand for larger coils. We had one inquiry recently for a furnace to handle slabs 26 ft long. On a conventional furnace this would be a long slab to handle. It means a large tonnage held in the furnace for a long time and metal losses would be high with high fuel consumption. However, with this "high-head" type of heating running it through end-wise, you do not care if the slab is 50 ft long.

C. A. Turner: Reference is made to conditioned slabs fed to the furnace. Is this conditioning over the full surface for removal of all prior mill scale? Is it reasonable to expect that these short heating cycles would minimize oxidation to the point of producing a negligible scale or film on the stainless grades? Are low alloy or plain carbon steel slabs processed? What is the scaling experience here? It was noted that in the event of a mill delay the slabs were rapidly removed from the furnace line by reversing the rolls. Do not those slabs in the high heat range scale when cooling in air? Must they be reconditioned?

The paper cites a 20 per cent improvement in heat transfer rate resulting from a proper burner selection and an intelligent design of the combustion chamber which aims to take full advantage of the forced convection effect. However, it is generally recognized that the maximum advantage by a forced convection effect results from a uniform, direct impingement of the

high velocity gases on the workpiece. In the furnace chamber described, the slab is surrounded by a ring of hot gases which must necessarily concentrate their impingement on the slab corners. This condition, coupled with the normal experience of faster heat pickup by radiation effects due to greater surface area at the corners, could create a problem in developing temperature uniformity over the slab width, especially in the early stages of heating. A soaking interval before discharge from the line could provide the ultimate uniformity, but might not overcome the edge damage by any early stage overheating.

In this connection, the author has noted that the heating practice is varied to achieve certain desired characteristics in the mill and cites edge checking and surface finish as two very important factors influenced by heating procedure. Does this imply a variation in practice which goes beyond a simple change in slab temperature level? Reference has been made to the difficulty experienced in developing temperature uniformity in the 400 grade stainless steels. This would seem to imply that this steel grade is more sensitive to edge checking by overheating than the 300 type. Is the temperature uniformity developed by reducing the furnace temperature head, slowing the line speed and operating with some sacrifice in production?

The author refers to the addition of ten more chambers to the line in 1957, amounting to a 46 per cent increase in line length and 50 per cent increase in the number of burners. Was this change designed to increase the originally planned production rate, or was it for the purpose of providing added soaking capacity for developing the uniform slab temperature? The curves of Figure 14 illustrate a typical heating cycle under present operating conditions and show all seven furnace zones operating under the same high temperature head of 2600 F. However, in the last four zones, the slab temperature shows a leveling off at 2200 F in spite of the 400 to 500 F furnace temperature head. Does this condition result from the cooling effects of the enlarged flue sections coupled with the contact with conveyor rolls at 1000 F?

Oscar J. Zanatta: The slabs are conditioned all over by grinding to eliminate any scale and also to provide a defect-free surface when entering the planetary mill. It has been found that any slab surface defect will be carried through the planetary mill and be reflected in the strip.

No experience with low alloy or plain carbon steel heating has been obtained with this unit. Consequently, we do not feel qualified to comment on this situation.

The slabs which are removed in the event of a mill delay and have been at or near rolling temperatures do scale when in contact with air. They are not reconditioned before rolling. The type of scale so produced is relatively thin and loose. On re-entry and reheating in the furnace, it is very easily scrubbed off by means of the hot gases directed around the slab.

In connection with Mr. Turner's question regarding heating practice to achieve best results in the mill concerning edge checking and surface finish, it has been found that furnace atmosphere, physical chamber condition, temperature, and speed all have a contributing effect on the final product. Mr. Turner, in his question on 400 grade stainless, implies that this grade is more sensitive to edge checking by overheating than the 300 grade stainless. This has not been proven conclusively in the operations at Atlas Steel. Edge checking has been controlled not by a reducing furnace temperature or slowing the line, but by proper balance of heat input by every burner.

The addition of ten more chambers to the length was designed to provide both added heating capacity and to give better control of soaking.

The answer to Mr. Turner's next question is rather difficult. The enlarged flue sections and the water cooled rolls do contribute to some extent to the leveling of the temperature curve at 2200 F when the furnace temperature is set at 2600 F. The grade of the steel, physical condition of the furnace, etc., also contribute to the deviation from the theoretical time-temperature curve.

W. M. Bloom: The author has pointed out that the furnace has utmost flexibility in a very restricted area with least capital expenditure, a relatively small charge in the furnace and utilizes a high furnace temperature head and a high velocity ring of hot gases around the slab to accelerate heat transfer rates.

Of the benefits mentioned by the author the acceleration of heat transfer rates appears to be the most important benefit. A greater heat transfer rate allows less time in the furnace. Less time in the furnace means less scale on the slab surface.

The author has referred to this type of heating as scale free. As scale buildup is a function of time and temperature, it is suspected that the process is not scale-free, but rather relatively scale-free, i.e., the scale coating formed would be thin in comparison to furnaces where the slabs are thicker and are in the furnace several hours.

If this method of heating is analyzed further, it is noted that between each furnace chamber the slab surface would have some time to transfer heat to the slab interior or soak. The slab surface is alternately and continuously heated to some higher temperature in a furnace chamber and then subsequently cooled between the two chambers. This alternate heating and cooling may well aid in prevention of surface overheating, which would prevent surface burning or slivers. This alternate slab surface heating and cooling may also affect the tightness of any scale formed due to the expansion and contraction of the scale. Perhaps the author can give us some more information as to whether or not he has a sliver problem and whether or not the time between furnace chambers for slab soaking reduces the sliver problem.

Mention was made in the paper that a closed end sight tube was used to measure furnace temperature and control the fuel-air input. It would seem that better control of the entire process could quite simply be obtained through use of an open end sight tube so that the thermopile would measure slab surface temperature instead of furnace temperature.

Also, in regards to the furnace fuel efficiency, it would seem logical to try to insulate the water-cooled rolls and reduce heat transfer from the heated slab to the rolls. Has the author tried to use a castable refractory roll covering imbedded on an alloy mat and welded to the steel surface for insulation together with steel support rings spaced along the roll length for slab

supports or any similar type of roll heat insulation?

Oscar J. Zanatta: With this type of furnace design and operation, there would be very poor temperature control if an open end sight tube is used. It was pointed out in the text of the paper that the entire slab is surrounded by the products of combustion, and some burning of the fuel takes place in the chamber. It becomes quite evident that under such conditions, it is impossible to obtain constant accurate temperature indication for control.

The problem of heat loss through the water-cooled rolls has given a great deal of concern. The lining of a roll with refractory operating under the extreme conditions mentioned is almost impossible. Severe conditions of shock caused by bowed slabs would certainly damage the rolls. Extreme heating and cooling would tend to spall a cast refractory from the roll even if an alloy mat were welded to the roll.

When the proper fuel-air ratio and furnace speed is maintained very little if any scale forms in the furnace. From observation on numerous heats, scale formation within the furnace was not observed. Some scale forms after the heated slab leaves the furnace between the furnace and the pinch rolls of the planetary assembly.

I. D. Akey: There is one question that rose in my mind purely from a technical application. The author mentioned that insofar as efficient operation is concerned there is no choice between either No. 2 fuel oil or natural gas. Have you had any experience in using fuel oil on some zones and gas on the other zones simultaneously, or are your controls set up so that you could not do it?

Oscar J. Zanatta: The occasion to operate the furnace on both gas and oil has never occurred. The burners and control set up is such that each individual zone can be operated as a separate furnace and no problem is anticipated. One, two or any combination of zones can be operated on gas or oil.

G. D. Cobaugh: The paper opened up a realm of monolithic refractory. Are any means of anchoring used in the monolithic refractory? What sort of luting material is used between the individual chambers, and how is expansion provided for one chamber. when taking another one out and putting a tailor-made chamber back in?

Oscar J. Zanatta: In answer to the question concerning anchoring of the cast refractory lining, it is pointed out that no steel or refractory anchors are used. The shape of the chamber gives a natural support to the refractory. There has been no difficulty with the refractory falling out or spalling away. The majority of chamber failures have been due to mechanical contact of the slab with the refractory walls separating the chambers. Experimentation is underway using precast shapes to form this section. Preliminary results are promising.

No luting material is used between the individual chambers and no expansion is allowed between the chambers. There is no problem in this respect.

J. E. Hovis: In this paper the author is talking of high speed heating. There are two ways to get it. One is exposure of steel surface; the other is high furnace temperature. In this case, we have the ideal condition with respect to surface because it is fully exposed. Furnace temperature is probably not quite at the ideal condition. The ideal condition is a constant furnace temperature. We suspect that the charge end runs at a temperature lower than 2650 F and gradually builds up to it which means reasonably high temperature in the discharge end to get this heating time.

You have roughly a 100-ft furnace. If we consider a 20-ft long slab, we could put five slabs in this hundred ft furnace. Likewise, if we consider nothing other than a simple pusher furnace, we could put five 20-in. wide slabs in an 8-ft 4 in. long furnace. The furnace, of course, would then be 24 ft wide. We would have full exposure of the slab surfaces, and have no edge heating problem. There would be practically no mechanical equipment on the furnace other than the pushers which are conventional and no problem. In recent years we are getting refractories that will allow one to put dry pier walls in a furnace of this type, capped with a special refractory. If you desire to get simple, let us ask the basic question: Why not a pusher furnace? Put the fuel where it has to be. In other words, the charge end of the furnace needs about three times as much fuel as the discharge end to keep this constant furnace temperature. What do we have? A constant high temperature furnace, a simple pusher furnace, full exposure of steel surface and very little mechanical equipment.

Oscar J. Zanatta: In this paper we are reporting only what is happening at Atlas Steel under present operating conditions. The first five zones are held very comfortably at 2600 to 2650 F. Zones 6 and 7 are held at a lower temperature to give the slab the final soak. There is no edge problem on 300 series stainless steel. Slight difficulties have been experienced with 400 series. However, with close check on balanced fuel input, this has been minimized and at present is almost negligible.

Member: I would like to add something here on the heating of low carbon steel since there have been some questions directed that way. There are two planetary mills on low carbon steel with the same style of heating. On the one the total heating time is roughly 7 min and the slab is above scaling temperature in a matter of about 2 min. So you can see the scale that is built up in the furnace is extremely light.

On top of this, the slabs coming to the furnace are selectively ground to remove scale and slivers and are wheel abraded to generally clean up the surface. Since they are being heated for only two min above the scaling temperature, the steel is extremely clean. The scale that is on there is extremely uniform and a reciprocating descaler with high pressure water makes the slabs very clean and results in very good surface strip.

Another point on low carbon rolling is on the edge heating where it comes up to a higher temperature than we would need, nevertheless the heat loss due to radiation from this greater surface at the edges makes it so that when it gets to the planetary rolls the over-all temperature of the slab is quite uniform. However, it is slightly high which makes for an extremely small amount of edge cracking. Generally speaking, you can say that the low carbon steel rolling on this type mill is equally as good as it is with stainless and high alloy steels. ▲

The Evolution of The Iron and Steel Industry

by DR. C. M. KRUGER
General Manager
South African Iron and Steel Industrial Corp.,
Pretoria, South Africa

The diamonds and gold of South Africa brought to light the need for a steel industry to supply the requirements of the country—yet the industry was not to become an actuality until the government realized its potential value and decided to sponsor its establishment.

AT the lower extremity of the huge African continent lies the Union of South Africa, richly endowed by nature with minerals of a great variety. About 300 years ago, when western civilization started to penetrate the "Dark Continent" from the extreme south, in a northerly direction, migratory Bantu tribes were moving southwards from Central African regions, bringing with them a rudimentary knowledge of iron metallurgy. Remnants of primitive furnaces of clay and stone have been found, in which, with clumsy bellows of hide and blowing pipes fashioned from clay-coated bamboo, or the horns of cattle, iron was smelted.

This product could be beaten into spearheads, but of plough-shares there was no need as these tribes were largely nomadic cattle raisers. White civilization, as represented by the Cape Colony, at the time a dependency of Great Britain, and the independent Boer Republics, was largely agrarian. The discovery, however, of South Africa's mineral wealth, especially diamonds and gold, during the latter half of the 19th century, changed the course of South African history and the pattern of life. The development of transportation and communication systems and the gradual establishment of secondary industry, related to the needs of the fast growing mining industry, gradually brought to light the need for an iron and steel industry.

In various parts of the country there successively appeared enthusiasts, who attempted to produce iron or steel, but with very little success, due to the very limited capital which they controlled and the small scale of their efforts. In the Transvaal the Central South African Railways also produced small quantities of iron from local ores in their Pretoria workshops. In 1905 a Mr. Anderson founded the Transvaal Iron and Steel Corp., Ltd., which purchased a rolling mill plant in New Zealand. The plant, however, was unsuitable and the venture failed. During the following year an open hearth furnace of somewhat novel design was erected in Johannesburg, but it failed to survive its first cast of metal and was abandoned.

In Natal, S. L. Green, the most successful of these early pioneers, built a blast furnace at Sweetwaters, near Pietermaritzburg. He coked his own coal, and using local ores, produced some two tons of pig iron. Shortage of suitable fluxing material stopped his experiment, but it was revived in 1909, when a dozen tons of pig iron were produced.

The beginning of a small, but permanent, iron and steel industry coincided more or less with the amalgamation of the four British colonies to form the Union of South Africa in 1910. Shortly before unification, the Government of the Transvaal, perturbed at the accumulation of scrap in the railway yards, called in an expert of repute to report on the situation. He recommended the establishment of an electro-smelting industry which would melt down the scrap for the making of steel. The government called for proposals to implement this suggestion and, after considerable delay, the tender of H. H. Wright was accepted by the Union Government. This venture was backed by the industrialist S. Marks and the Union Steel Corp. of South Africa was formed. In 1913 the first steel was poured from a 10-ton open hearth furnace at Vereeniging.

This firm, commonly referred to as USCO, is to this day playing an important part in the Union of South Africa's steel industry.

While these events were taking place C. F. Delfos, an engineer of Pretoria had refused to tender for the scrap metal contract, because he held that the manufacture of steel from scrap would only delay the ultimate establishment of an industry based on the country's own ores. He was interested in establishing an industry exploiting the ores available on the Pretoria townlands and persisted until he obtained the concession and founded the Pretoria Iron Mines Ltd., in 1917. His small blast furnace produced good foundry iron in 1918 (but was stopped when the influenza epidemic interfered with operations). After enlargement, the furnace was operated intermittently and produced 4000 tons in all, before it was shut down in 1921.

Another attempt to establish an iron and steel industry was made by J. K. Eaton. From his efforts resulted the firm, which today operates as the Dunswart Iron and Steelworks, Ltd., at Benoni, in the Transvaal. He also started preparations for the erection of a blast furnace at Newcastle, Natal, which, however, did not come into operation until 1926, by which time it had been acquired by USCO, referred to above.

In South Africa

ISCOR

Despite all the failures and small beginnings, Delfos firmly believed that the idea of an iron and steel industry in the Union was feasible. The growth of industry generally was slow, as South Africa, a gold producer, was able to import her requirements. Overseas investors showed little interest in the establishment of heavy industry in South Africa, as dependencies were looked upon as sources of raw materials and as markets for manufactured products. Delfos was convinced that only by obtaining government interest and assistance could a steel industry be established successfully. The government ultimately realized the potential value of such a basic industry and decided to sponsor its establishment.

After protracted debates, stretching over several sessions of Parliament (including a joint session of the Senate and House of Assembly), the bill introduced by the government was passed and put on the statute book in 1928, making provision for the establishment of the South African Iron and Steel Industrial Corp. Ltd. (ISCOR).

The act provided for the formation of a company " . . . to carry on the trades or business of iron masters, steel makers, steel converters, colliery proprietors, coke manufacturers, miners, smelters, engineers and iron founders in all their respective branches, and to manufacture, manipulate, buy, sell, exchange or otherwise deal in iron and steel . . . " In the act provision was made for a capital structure of £3,500,000 consisting of £500,000 government held "A" shares, £3,000,000 "B" shares to be offered to the public and a loan of £1,500,000 in debentures. (At present exchange rate £1 is approximately equal to $2.815.)

Furthermore the act stipulated that the operations of the Corp. ". . . shall . . . be managed and controlled by a board of directors, which shall consist of seven members . . . " of whom four, including the chairman, would be appointed by the holder of the "A" shares (government) and three by the holders of the "B" shares (the public).

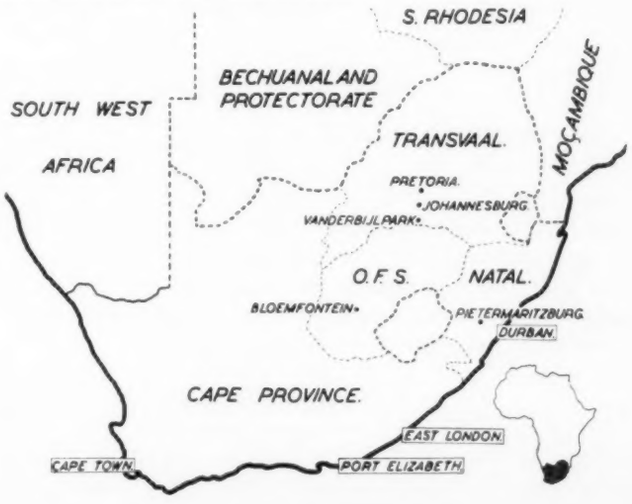
The aim of the act was the creation of a mixed, or semi-state industry, in which government control would be accompanied by the widest public participation. No provision was made for direct state control of the operations of the corporation. These would be directed by the board of directors, who would be fully responsible for its affairs. Neither the directors, nor the employees were to be considered as members of the public service.

As so often occurs when a matter becomes a political issue, much open hostility and criticism had been fomented during the debate on the creation of a South African iron and steel industry. This, together with the shortage of capital, because of the depression at the time, resulted in the public not taking up the "B" shares, as was hoped. The initial offering drew less than £7,000 although progressively a total of £219,636 "B" shares was taken up by the public.

When it was clear that public support was not forthcoming, the government, who had underwritten the share issue, had no alternative but to subscribe for the balance. The result was that the government became the major shareholder. The financial aspect will be touched upon again later.

Thus, C. F. Delfos' cherished vision of an integrated steel industry was beginning to materialize. In 1930 clearing of a site started, about five miles west of the centre of Pretoria city (Figure 1) and in March 1934 the first 500-ton blast furnace was blown in. In April the first steel ingots were poured from the open hearth plant and rolled into sections. It is now history how

Figure 1 — The map of the Union of South Africa shows the centers of metal production.



Iscor, practically from the start, had to devise ways and means to increase production. The contemplated 180,000 ingot tons were not sufficient to meet the Union's steel requirements, which started to snowball after the depression years of the early thirties.

DR. VAN DER BIJL

During this period Iscor was fortunate to have as chairman of the board, Dr. H. J. van der Bijl. (He may be known to American audiences as the physicist noted for his contribution towards the development of the thermionic vacuum tube, the construction of the first trans-continental telephone line and the wireless transmission of speech between America and the Eiffel Tower in 1915.)

As head of the Electricity Supply Commission, as well as the steel industry, Van der Bijl was in control of the twin forces, which were to contribute greatly to South Africa's growth—electricity and steel.

To try to narrow the gap between supply and demand, the history of the corporation is marked by continual expansion and modernization schemes. Just before the outbreak of the second world war, the annual production had been increased to about 350,000 tons. During the war the corporation had to shoulder new burdens and responsibilities and in 1942 the first steps were taken towards the establishment of a second, fully integrated, steel works on a new site, on the Vaal River, 35 miles south of Johannesburg. In spite of considerable opposition again, the government agreed to the inauguration of a scheme, three times as big and far more than three times as costly as the original Pretoria scheme, principally on the guarantee of Van der Bijl's faith. On this site the new town of Vanderbijlpark sprang up and in 1943 the first plates were rolled, in a 110-in. plate mill, from slabs from the Pretoria Works.

Dr. van der Bijl's association with the steel industry brought home forcibly to him the extent to which some of South Africa's base metal resources were being neglected and others squandered, by the export of high grade ores. With the approval of the Iscor Board, he formed African Metals Corp. Ltd. (AMCOR), in 1937, to develop this side of the Union's economy. This company, today, in addition to supplying the bulk of the Union's demand for foundry pig irons and ferro-alloys, is building up a new and very important export business for the country, by exporting ferro-alloys instead of raw ores.

POSTWAR PERIOD

At the end of World War II, Iscor's ingot production at the Pretoria Works had risen to just over a half million tons. Except for an issue of £2,500,000 of ordinary shares during 1933/35, extensions up to 1943 were financed entirely from the corporation's own resources. The gap between supply and demand was widened, however, by the aftermath of the war and the corporation embarked upon major expansion schemes.

PRETORIA WORKS

At this time the facilities of the corporation consisted of the following major items: two coke oven batteries with by-product plant; three blast furnaces, one with a hearth of 16 ft-1 in., and two with 18-ft hearths; a steel melting plant comprising a 500-ton inactive mixer, one 220-ton and two 150-ton tilting basic open hearth furnaces and three 25-ton acid bessemer converters. The production of steel, at this Works, is based on the consumption of relatively large quantities of fluid metal from the blast furnaces, using the duplex process. In the mills complex the original heavy mill, consisting of cogging, roughing and finishing 2-high reversing stands in line, driven by a single 5600-hp motor, had been modified by the installation of a second identical motor, to drive the roughing and finishing stands from the finishing end. A separate 44-in., 2-high blooming mill was installed in 1943 and a three-stand, 3-high 21-in. medium mill in 1944, to relieve the 2-high reversing heavy mill of the intermediate weight profile sections and semis.

The light mill consisted of a combination bar and rod mill, of two groups of continuous roughing stands, first three and then four, with eight open train stands in staggered formation, with a 5 stand continuous rod train at the end. From the fifth stand in the open staggered train delivery was made onto a cooling bed.

In 1942 a self-built 6-stand, 3-high small section mill was commissioned to roll tool steel, and subsequently, window sections, small angles and flats. The same year also saw the establishment of a wire plant with drawbenches, looms, etc., which was gradually extended to produce about 60,000 tons per annum of finished wire products. Other facilities included a hand type sheet works, for 80,000 tons annually of galvanized and uncoated sheets, a bright steel shafting plant for bright bars, ½ to 6-in. diam and a 3000-ton forge press.

The postwar extension schemes provided for considerable modernization, as well as additional capacity. More coke oven batteries were built, bringing the total to the present 160 top charged ovens, with a throughput of 3600 tons of coal per day. The heavy mills complex was amplified by the addition of a 6-stand 2-high continuous billet mill, in 1954, which brought its combined capacity to 850,000 ingot tons per annum. In the light mills complex, the rod train was separated from the bar mill in 1951 and 15 continuous roughing and intermediate stands were added in line, ahead of the five wire rod stands of the original mill, to establish a separately operating rod mill. This converted rod mill increased the capacity of rod from 32,000 ton to 110,000 tons per annum and enabled the balance of the original bar mill, with five open stands, to increase its capacity in merchant bar, light sections and semis, from 71,500 to 150,000 tons per annum. For the purpose of these extensions Parliament had authorized, in 1943, an increase in Iscor's share capital of £6,500,000 ordinary shares, but it was soon to be asked to back the confidence of the Iscor Board once more for further extensions.

VANDERBIJLPARK WORKS

At the close of World War II the opportunity presented itself to forge ahead with the plans for the second fully integrated steel works at Vanderbijlpark. The 110-in. plate mill on this new site had already been rolling since 1943, on slabs from the Pretoria Works. Parliament authorized the creation of a further 15,000,-

000 ordinary shares, which at 10/-premium per share, represented an investment of £22,500,000 for this project. Additional funds were provided by the issue of £8,000,000 debentures, under government guarantee. It may be of interest to Americans to know that although the bulk of the equipment for this new works was of American origin and that upwards of 50 of the corporation's officials and operatives were trained in the U. S. under a technical aid and license agreement with a well-known U. S. company, all of this was paid for out of South African funds. At no time has South Africa been a beneficiary of Marshall Aid in any form.

With the untimely death of Dr. van der Bijl in 1948, chairmanship of the Iscor Board passed to Dr. F. Meyer. He brought to the Board an unrivaled knowledge of Iscor. As confident and trusted adviser of the ministers responsible for the introduction of the Iron and Steel Industry Bill and later as chief executive of the corporation, he had been intimately concerned with the building of Iscor from its inception. In a post-war period of rising costs and world steel shortage, he had the formidable task of establishing an additional new works and expanding its attendant town.

EXPANSION

Construction proceeded apace and in 1950 the first steel was tapped in the Vanderbijlpark Works which today comprises the following: two coke oven batteries with 99 ovens; two blast furnaces of 21-ft 6-in. hearth producing 1100 tons each per day; a steel melting plant with five fixed open hearth furnaces of 200 tons each, with an overall ingot capacity of 900,000 tons per annum; and the mills complex for flat products.

The hot mills division comprises: a 2-high 46-in. slabbing mill with slab shear; two slab reheating furnaces; a 4-high 110-in. reversing plate mill (with vertical edger), which is also the roughing mill for the continuous 6-stand 4-high 56-in. hot strip mill; together with coilers and the necessary plate finishing equipment.

The cold mill complex is equipped with a continuous strip pickler, a 56-in. 4-high 4-stand tandem cold mill for rolling sheet and tinplate stock, two sendzimir continuous galvanizing lines, an alkaline cleaning line,

Figure 2 — All materials must be transported by rail since there is little river transportation.

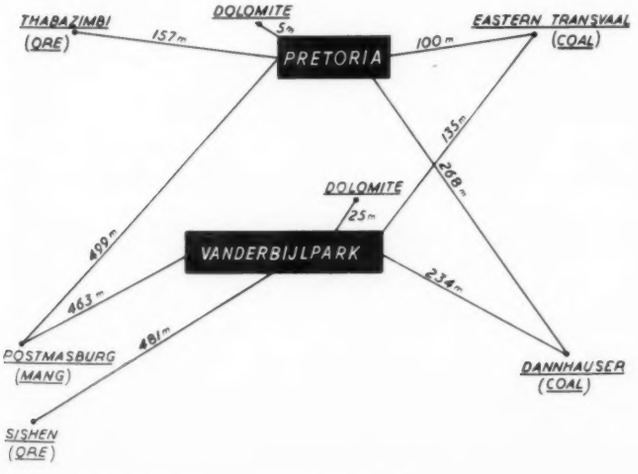


Figure 3 — Hematite ore is mined at the Thabazimbi mine both in open quarries and on three underground levels. A beneficiation plant is shown at the base of the mine.

Figure 4 — The mine at Sishen provides hematite ore for the Vanderbijlpark Works.

16 4-pedestal coil annealing bases and direct gas-fired furnaces, sheet annealing equipment, coil and sheet temper mills, shear lines, etc., and four hot dip tin stacks.

Today, after 25 years of production, Iscor is responsible for about 90 per cent of the steel produced in the Union, equivalent to about two-thirds of the country's steel requirements.

RAW MATERIALS

These two steel works of Iscor are both located in close proximity to the Witwatersrand area, the most highly industrialized area of the Union and consequently Iscor's major market. Because of its peculiar topography of a high central plateau, extending to a 3000-ft escarpment near its coasts, South Africa has no navigable rivers and materials have to be hauled by

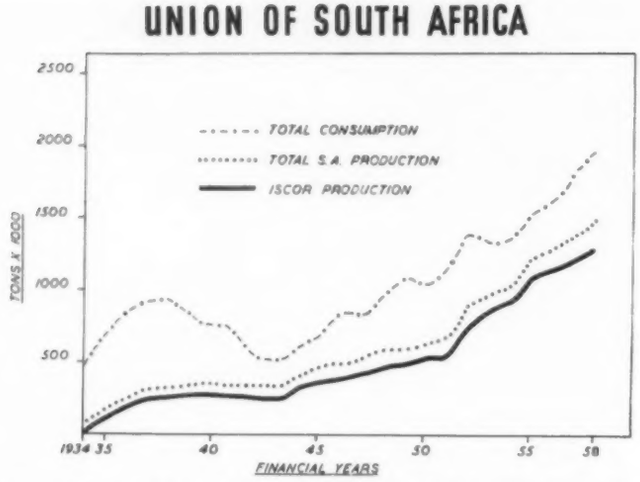


Figure 5 — The availability of rolled and drawn steel, in the Union of South Africa, relative to the actual usage, indicates that production has difficulty in keeping pace with increasing demand.

rail (Figure 2). In the initial stages some quartzitic iron ore, adjoining the works site, was used in the blast furnaces at Pretoria, but this was abandoned in favor of the hematite ore, similar to that of the Mesabi Range, from the corporation's Thabazimbi (Mountain of Iron) iron mine (Figure 3). This deposit of more than 80,000,000 tons of high grade ore, together with a much larger quantity of lower grade ore, is about 155 miles by rail from Pretoria. The high grade ore has an average composition of better than 60 per cent Fe, with very low percentages of deleterious materials. Beneficiation and ore bedding are done to provide the blast furnaces with material of uniform composition. The blast furnaces at Vanderbijlpark are supplied from another corporation-owned high grade deposit at Sishen (Figure 4), 480 miles away by rail. Known reserves of ore there, of more than 60 per cent Fe, amount to over 400,000,000 tons.

Coal is very plentiful in South Africa. The deposits nearest the works, however, are of high ash content and relatively poor coking quality. The corporation therefore uses two types: a straight coking coal from its own colliery at Dannhauser, with reserves of 80,000,000 tons, 260 miles from Pretoria; and blend coking coals purchased from various companies in the Eastern Transvaal, about 100 miles from Pretoria. The corporation has also acquired rights in a new field of blend coking coal in the Northern Transvaal (Waterberg), where the reserves amount to several hundreds of million tons.

Metallurgical dolomite, carrying less than 3 per cent silica, is available in huge reserves to both the Pretoria and Vanderbijlpark plants. About five miles west of Pretoria, the corporation operates a quarry, where the deposit is of the order of 400,000,000 tons, with more in depth. The Vanderbijlpark Works will, in the near future, be supplied from Glen Douglas, about 25 miles away. The reserves here and on the adjoining property, which the corporation has also acquired, exceed 200,000,000 tons.

At present the corporation does not produce its own limestone, but buys its requirements from outside concerns. It however holds claims in the Cape Province over huge reserves, which could be exploited, if the need should arise. The more important deposit, of 320,000,000 tons, is near Oudtshoorn, 800 miles from Pretoria.

Manganese ore is obtained from the Postmasburg area, 40 miles from the corporation's iron ore mine at Sishen, and ferro-alloys from African Metals Corp., an associate of Iscor.

THE MARKET

South African steel is the cheapest in the world. This has undoubtedly acted as an additional stimulus towards the expansion of secondary industry in the Union. Figure 5 shows the marked rise in steel demand since 1934, when Iscor entered the local market, and the way in which the South African iron and steel industry has tried to keep pace with it. Table I shows a breakdown, into broad product classes, of local production and imports for the past financial year and also the estimated demand for the year 1960/61. The table also lists exports for the past year. Although South Africa is only three quarters self-sufficient in respect of its steel requirements, it must necessarily shoulder the responsibility of acting also as a convenient supplier to nearby territories in Africa. Exports to these areas consist mostly of structural steel, sheets and fabricated articles such as drums, pipes and fittings, wire and wire rope, etc., although shipments also go as far afield as Europe, Ceylon and New Zealand.

TABLE I
Consumption of Rolled and Drawn Steel—Union of South Africa
Thousands of Tons

Products	Year: July, 1957 to June 1958			Estimated Local Demand 1960/1961	Exports 1957/1958
	South African Steel Producers	Imports	Total Consumption		
Billets and blooms (excluding semis supplied to South African re-rollers)	93.1	1.5	94.6	88.0	0.3
Sections, bars and rods (including bolts, nuts, rivets and chains, but excluding wire rod)	533.0	121.3	654.3	648.0	25.7
Rails and rail accessories	91.8	154.1	245.9	224.0	0.4
Plates	249.0	38.2	287.2	295.0	4.8
Sheet, strip and hoop	364.4	12.1	376.5	454.0	26.3
Tinplate and blackplate	36.3	67.2	103.5	100.0	0.2
Wire rod, wire and wire products (including nails and screws)	107.9	55.3	163.2	186.0	6.1
Drill and tool steel	11.7	1.5	13.2	14.0	0.2
Miscellaneous	...	22.2	22.2	93.0	15.2
Total	1487.2	473.4	1960.6	2102.0	78.9
Ingot Tons on the basis of an over all yield of 80 per cent			2450.8	2627.0	

FURTHER EXPANSION

In view of the steep rise in the demand for steel, the Iscor Board decided, about three years ago, to embark on a further expansion and modernization scheme, at an estimated cost of £56,000,000. This expenditure is being financed out of earnings and reserves created over the years.

At the Pretoria Works (Figure 6) these extensions include; the fourth blast furnace with 25-ft hearth diameter, which was blown in in July, 1958; a new sinter plant; a 75-ton electric furnace in the steel melting plant; and the following items still under construction.

1. A new steel melting plant shop with a 900-ton mixer, 150-ton charging and casting cranes, an oxygen rotor plant (Figure 7) with two vessels and a tonnage oxygen plant. This plant is expected to produce 300,000 tons ingots per annum.
2. A calcining plant of five shaft kilns to provide sintered dolomite.
3. Extensions to the heavy mills complex comprising additions to soaking pits and reheating furnaces; four roughing "cross country" 2-high stands ahead of the existing continuous billet mill enabling it to take larger blooms; a 2-high, 29-in. reversing blooming mill to be added ahead of the present medium mill; as well as a 21-in., 2-high finishing stand, with a separate vertical edging unit.
4. A new 24-stand rod mill to produce rod to close tolerances, at speeds up to 6000 fpm (equipped initially for 3-strand rolling but capable of later conversion to 4-strand rolling); the old rod mill to be converted to an alternative bar rolling train feeding onto the existing merchant mill cooling bed.
5. A new fully mechanized small section mill, to roll window sections and material for cold heading stock, consisting of a 5-stand continuous roughing train, with three horizontal and two vertical stands, followed by an 8-stand staggered open train and a 3-stand continuous finishing train (one horizontal and two vertical stands).
6. Additions to the wire plant to raise its capacity from 66,000 to 100,000 tons per annum.

The extensions and modifications are summarized in Table II which also shows present and projected plant capacities.

At the Vanderbijlpark Works (Figure 8) extensions are underway to increase capacity to 1,250,000 ingot tons per annum. These include:

1. A third coke oven battery of 55 ovens, which is nearing completion.
2. Alteration of the two existing blast furnaces by the provision of a carbon annulus and extra tuyeres and enlargement of the hearth diameter to 23 ft-0 in.
3. An oxygen rotor steel furnace, with tonnage oxygen plant, with a capacity of 300,000 ingot tons per annum.

Figure 6 — The Pretoria Works has recently added a fourth blast furnace, a new sinter plant, and a 75-ton electric furnace.

Figure 7 — Iscor has decided to install an oxygen rotor furnace plant with two vessels. This plant is shown during construction at right center of the illustration.

4. Conversion of three of the existing open hearth furnaces to tar firing.

The increased steel tonnage will necessitate additions and modifications to the mills as follows:

1. The construction of a second slab yard 95 x 500 ft.
2. Enlargement of the two existing slab furnaces to 120 tons per hr each, as well as the construction of a third reheating furnace of 130 tons per hr.
3. Installation of a 2-high scalebreaker ahead of the existing combined 110-in. plate and roughing mill, along with extensive modernization of the mill itself, which will in the future continue to act as only a roughing mill for the hot strip mill.
4. Construction of a new 144-in. 4-high plate mill, complete with scalebreaker, hot leveler, cooling and inspection beds, and $^3/_4$-in. shearing line consisting of crop shear, rotary side trimmer and splitter and end shear with cold leveler and plate pilers.
5. Relocation of the existing plate shears, to operate as a $1^1/_4$-in. shearing line in the new plate mill finishing bay.
6. Construction of a $^3/_{16}$-in. shearing line for hot rolled sheets.
7. Construction of a $^1/_4$-in. slitting line for hot rolled slit strip.
8. Equipment for improved scrubbing and cleaning on the alkaline strip cleaning line.
9. Additional coil annealing equipment.
10. Modernization of the existing 56-in. sheet shearing line.
11. Conversion of the existing $^3/_{16}$-in. slitter to a coil rewind line.

Table III shows how these extensions will affect plant capacities at the Vanderbijlpark Works.

THE INDEPENDENTS

Although Iscor is responsible for 90 per cent of the steel made in South Africa and the activities of the corporation therefore closely reflect, for all practical purposes, the country's iron and steel industry as such, the independents have played a not insignificant role in South Africa's economy. Through the years they have catered for jobbing orders and provided South Africa with a variety of specialities, such as tool and drill steels and in their turn have thus kept pace with the growth of secondary industry.

THE FINANCIAL AND CORPORATE ASPECTS

The first year's business of Iscor, as was to be expected, resulted in a loss of just over £250,000, but by June, 1936, over the 18 months' period January, 1935 to June, 1936, a profit of £340,000 was earned.

TABLE II

Pretoria Works of the South African Iron and Steel Industrial Corp., Ltd.

Plant	Technical details		Annual Production, tons	
	Present	Extensions, modifications in hand or contemplated	Present	Contemplated after Extensions
Coke ovens	160 top charged ovens, Becker regenerative type	...	920,000	920,000
Blast furnaces	One hearth diameter 16 ft-1 in. Two hearth diameter 18 ft-0 in. One hearth diameter 25 ft-0 in.	...	1,100,000	1,100,000
Steel melting plant	One 500-ton inactive mixer One 220-ton tilting basic open hearth furnace Two 150-ton tilting basic open hearth furnaces Three 25-ton acid converters One 750-ton mixer for bessemer iron open hearth One 75-ton 15,000-kva electric furnace	Additional: 1000-ton mixer 100-ton rotor installation Tonnage oxygen plant	850,000	1,150,000 (ingots)
Soaking pits and reheating furnaces	16 pits and 4 bloom reheating furnaces	Four additional pits, and 1 additional bloom reheating pusher furnace (for the medium mill)	850,000	1,150,000 (ingots)
Blooming mill	44-in., 2-high reversing	...	850,000	1,150,000 (ingots)
Billet mill	27 in. 2-high, 2-stand 23 in. 2-high, 4-stand Both continuous	Four additional roughing stands ahead of existing 6-stand billet mill, as follows: 31½ in. 2-high, 2 stand Both 29½-in. 2-high, 2 stand cross country	300,000	450,000 (output)
Heavy mill	33-in., 2-high, reversing, 1 stand 30¾-in., 2-high, reversing, 2 stand (Both in line)	...	285,000	285,000 (output)
Medium mill	21-in., 3-high, 3-stand in line	One additional 29-in., 2-high, reversing roughing stand A fourth 21-in., 2-high staggered finishing stand A vertical edging stand	160,000	200,000 (output)
Merchant bar mill	15-in. 2-high, 3-stand continuous 12-in. 2-high, 4-stand continuous 12-in. 2 or 3-high, 5-stand staggered	Existing (separate) rod mill, to be converted to an alternative bar rolling train connected to the existing merchant mill cooling bed	150,000	160,000 (output)
Rod mill	16-in. 2-high, 3-stand 14-in. 2-high, 3-stand (All 12-in. 2-high, 9-stand continuous) 11¼-in. 2-high, 5-stand	18-in. 2-high, 2-Stand Stands 1–12, straight continuous; stands 13–16, straight continuous; stands 17–18, staggered; stand 19–24, straight continuous, mechanically coupled, loops between stands 12 and 13, 16 and 17, 17 and 18 and 18 and 19 16½-in. 2-high, 4-stand 15-in. 2-high, 4-stand 13½-in. 2-high, 4-stand 12-in. 2-high, 4-stand 10-in. 2-high, 6-stand	110,000	180,000 (output) (2 shift operation)
Small section mill	12-in. 2- or 3-high, 6 stands in line	New mill: 16½-in. 2-high, 5-stand (3 horizontal and 2 vertical), continuous 13-in. 2-high, 8-stand, staggered 13-in. 2-high, 3-stand (1 horizontal and 2 vertical)	30,000	70,000 (output) (2 shift operation)
Wire works	Drawbenches..... 22 Barbing machines..... 15 Wire netting looms..... 5 Patenting line..... 1 Galvanizing lines..... 3 Annealing furnaces..... 6	Additional units: Drawbenches..... 12 Barbing machines..... 2 Wire netting looms..... 1 Patenting line—more take-up reels on existing line Galvanizing lines..... 1 Annealing furnaces..(reconstructed)	66,000	100,000 (output)
Forge press	3000-ton hydraulic	...	4300	6000 (output)
Bright steel shafting plant	One 7-in. bar turner One 3-in bar turner One ½–⅞-in. centreless grinder	...	7800	7800 (output)

The public immediately started showing interest in this new industry, as it became clear that it was not going to be the white elephant, that had been predicted by some, but a financial success. The government decided, however, that it would retain all its shares, which would make it easier for one of their main aims in establishing this industry to be implemented. This aim was to encourage the expansion of the industry, while main-

Figure 8 — Vanderbijlpark Works is planning an expansion to increase its capacity to 1,250,000 ingot tons per year. A third coke oven battery, the alteration of two existing blast furnaces and an oxgyen rotor plant will contribute greatly to the achievement of this figure.

taining the lowest possible selling prices for the steel produced. It was decided that the state would be prepared to receive in dividends on its shareholding, a return equal more or less to the interest on the funds invested by it in the venture. So as not to be unfair to the minority shareholders, that small band in the public, that had been willing to invest in the new venture originally, the public holding of £219,000 odd was converted, with the permission of the owners of the shares, to 7½ per cent preference shares. The state thus holds 100 per cent of the voting shares and appoints all the directors on the board. This change was not a move inspired by sinister motives but merely to enable Iscor to plough back more of its earnings into the venture. There has been no change in the policy by the state of noninterference in the running of the affairs of the company. What has been the result is that today this venture, with an authorized and issued share capital of £25,400,000 owns assets of an original cost value of over £134,000,000, the difference having come largely from its own earnings. As has been indicated above, this company is at present embarked on an expansion program which will require the future expenditure of over £56,000,000, which expenditure will be financed wholly out of its own resources, and without increasing its issued share capital.

Here we thus have in Iscor a corporation, which is a state sponsored organization, in the sense that the government has invested in it large sums of money, but it is for all practical purposes run and organized as an independent public corporation. It has had to compete, like any newcomer to the field, with older established firms in the western economy. It has to pay Union and Provincial taxes and to date Iscor has contributed over £30,000,000 to the state coffers. Regarding dividends, as mentioned, the position is that the dividends received by the state should not, on average, yield a return of less than the cost to the state of borrowing the funds invested in Iscor. The dividend rate has thus for many years been 4 per cent but it has always been understood that the state would be prepared to accept a lower dividend on its shareholding, if this became necessary, so as to maintain steel prices at a low level. The corporation has, however, succeeded, in a large measure, in keeping steel prices down, without lowering the dividend rate, and at the same time building up reserves for its expansion programs. Its assets today as mentioned, at original cost, are in excess of £134,000,000 and it can look back on 25 years of production and great achievement in the service of South Africa. In that period it has produced over £323,000,000 ($1,000,000,000) worth of steel and has made it available to South African industry at a price which, under normal conditions, is today an average £22 ($60) per ton less than that of imported steel delivered in the Witwatersrand area, i.e., within 150 miles of the works, where the main market is concentrated. Iscor has, notwithstanding steady rises in costs, due to factors beyond its control, been able, through close attention to improving efficiency coupled with the advantages accruing from progressively increased outputs, to maintain its selling prices at a constant level since 1952. Compared with prewar prices, Iscor steel has to date risen by 120 per cent compared with 270 per cent in the United Kingdom and 165 per cent in the U. S. home markets.

UNION STEEL CORPORATION (USCO)

Mention has been made of the way in which the accumulation of steel scrap in the railway yards led to the establishment of the Union Steel Corp. of S.A. Ltd. at Vereeniging on the Vaal River in 1912. The initial equipment at the Vaal Works consisted of:

One 10 to 12-ton Siemens open hearth furnace.
One 600-ton press.
Two Siemens reheating furnaces.
One 12-in. merchant bar rolling mill.

The infant industry prospered and expanded. In 1917 a 15-in. finishing mill was commissioned (enlarged to 16-in. in 1952) and in 1918 steelmaking capacity was increased by the addition of a 30-ton open hearth furnace and a 3½-ton electric arc furnace. This was followed in 1922 by a 40-ton open hearth furnace, 12-in. odd section mill (1925) and 45-ton open hearth furnace (1928).

With the establishment of Iscor, the field of produc-

TABLE III

Vanderbijlpark Works of the South African Iron and Steel Industrial Corp., Ltd.

Plant	Technical details		Annual production—tons	
	Present	Extensions/modifications—in hand or contemplated	Present	Contemplated, after extensions
Coke ovens	109 top charged ovens, Becker regenerative type	55 ovens to be completed, 1959	541,000	920,000
Blast furnaces	Two hearth diameter 21 ft 6 in.	Carbon annuli and additional tuyeres. Hearths to be increased to 23 ft diameter	776,000	945,000
Steel melting	Five 200 ton open hearth furnaces, stationary	Three furnaces to be converted to tar firing. Additional: 11,000-ton mixer 100-ton rotor installation 100-ton rotor installation with tonnage oxygen plant	885,000	1,250,000 (ingots)
Soaking pits	14 pits—90/100 ton	Additional: 2 pits—90/100 ton		
Slab mill	46-in. 2-high reversing	.....	885,000	1,250,000 (ingots)
Slab furnaces	2 Furnaces 18 x 80 ft 100 tons per hour	Existing furnaces enlarged to 120 ton per hr. One additional slab furnace, 23 x 88 ft—130 tons per hr.	760,000	1,150,000 (slabs)
Hot mills	110-in. 4-high, 1 stand, with vertical edger, plate and roughing mill 56-in. 4-high, 6-stand, hot strip mill Plate shears ¼-in. shearing line 2-high skin pass mill	Scalebreaker, 2-high, 36 x 70 in. Additional d-c generator and modernization of auxiliaries. New 144-in. 4-high plate mill with scalebreaker, hot leveller, and ¾-in. shearing line. Relocation and modification to operate as 1¼-in. shearing line. New $\frac{3}{16}$ x 52-in. shearing line, incorporating existing plant. New ¼ x 54 in. slitting line.	367,000 Finished Products	609,000
Cold mills	56-in. continuous pickling line Batch sheet pickler 56-in. 4-high 4-stand tandem cold mill Two 48-in. continuous galvanizing lines, sendzimir process, 225 fpm $\frac{3}{16}$-in. slitting line 16-gage slitting line 42-in. alkaline cleaning line 16 coil annealing bases, 4-pedestal, 176 tons 6 sheet annealing bases, 60 tons 2 sheet annealing bases, electric furnace 56-in. sheet shearing line, 600 fpm 42-in. tinplate, shearing line, 1000 fpm 56-in. 4-high coil temper mill Four 75-in. hot dip tin stacks	Various relatively minor modifications and extensions.	286,000 Finished Products	373,000

tion was reviewed and USCO has concentrated its production in the field of lighter steel sections and particularly in the manufacture and rolling of special and alloy steels. The complementary nature of this policy has enabled the smaller private enterprise not only to co-exist alongside of the larger state-owned Iscor, but also to expand its activities. Further additions and modernization resulted.

The Vaal Works now comprises:

Melting Shop	Annual capacity
Two 45-ton open hearth furnaces.	
One 60-ton open hearth furnace.	
Three 3½-ton electric arc furnaces	139,000 tons
Rolling mills	
One 22-in. cogging mill.	
One 12 to 16-in. finishing mill.	
Two 12-in. finishing mills.	173,000 tons
Steel foundry	7,000 tons
Iron foundry	3,000 tons

Extensions now underway include the laying down of a new 16-in. mill, additional soaking pits, a 2-stage gas producer and extensions to the steel foundry.

USCO had also established a rod and wire mill in 1926 on the nearby Klip Works site for the manufacture of steel wire. In 1931 it was decided to embark upon the manufacture of hollow drill steel for use in the Witwatersrand gold mines and two 1½-ton electric arc furnaces were installed. The manufacture of special steels has remained concentrated at Klip Works, where an additional plant has been installed over the years, to produce, in addition to the hollow drill steel for mining, also tool, shock-resisting, heat-resisting, three-ply, solid drill and many other alloy and special purpose steels. This plant now comprises:

Melting Shop:
- Two 10-ton electric arc furnaces
- Three 3½-ton electric arc furnaces
- One 1½-ton electric arc furnace
- One high frequency induction furnace, 1 ton and ½ ton
- Total output: 32,000 ingot tons per annum

Rolling Mills:
- One 16-in. cogging mill
- One 16-in. and 12-in. tandem finishing mill

At the Klip Works are also located:

1. Steel rod and wire department with continuous 17-stand rod mill for 35,000 tons per annum and wire mill.
2. Forge shop.
3. Annealing and heat treatment plant.
4. Copper wire department for electrolytic copper wire, conductor and strip.
5. Aluminium wire department for aluminium wire and steel-cored and plain aluminium conductor.

Subsidiaries of USCO, viz, S. A. Bolts and Nuts (Pty.) Ltd., and African Disc Co. (Pty.) Ltd., at Vereeniging, produce over 10,000 tons of bolts, nuts, screws and other fasteners and 840,000 plough discs and other earth engaging parts per annum, respectively.

DUNSWART IRON AND STEEL

As mentioned earlier, the efforts of J. K. Eaton resulted in the establishment in 1911, of the Union Iron and Steel Works, which operated the first rolling mill in South Africa. The products of this company, subsequently renamed Dunswart Iron and Steel Works Ltd., at first consisted mainly of rolled sections manufactured from puddled and fagotted wrought iron. In 1920 attention was given to the manufacture of steel and two basic electric arc furnaces were installed along with an 18-in. cogging mill. Melting capacity was increased by the installation, in 1935, of a third electric furnace, and in 1946, of an acid electric melting furnace, the latter more particularly for its mass production steel foundry.

In 1951 an attempt was made to meet the continually rising demand for molten steel, by the installation of converters, followed in 1954 by the decision for major plant expansion and modernization, involving an expenditure of £2,000,000. A new electric melting department—buildings, gantries, melting units, laboratory, etc.—was superimposed over the old plant and followed by the erection of a medium section mill, combined cogging and finishing mill, combination light section mill and auxiliaries. Further expansion and modernization of the steel foundries are contemplated.

The existing plant of Messrs. Dunswart now comprises the following:

Melting department	Annual capacity (short tons)
One 15-ton basic electric arc furnace	36,000
Two 10-ton basic electric arc furnaces	48,000
Two 5-ton basic electric arc furnaces	21,000
One 3-ton acid electric arc furnace	5,000
One 300-kg radiation furnace	250
Rolling mills	
One 22 to 18-in cogging and heavy section mill	70,000
One 18-in. cogging and finishing mill	24,000
One 12-in. medium section mill	25,000
One combination light section mill, 450/300 mm. (17.7 to 11.8 in.)	36,000
Steel foundry	8,000

SCAW METALS LIMITED

As a result of the rapid expansion of its iron founding business in Johannesburg, this company started the production of grinding balls for the gold mines in 1941. At its new works at Union Junction, the metal was poured from three 3-ton direct arc furnaces into a special ball casting machine. In 1946 it acquired the shareholding of the Chamber of Mines Steel Products Ltd., and operated the latter's works at Driehoek, for the production of shoes and dies for stamp batteries and of grinding balls, forged from billet sized ingots, in a ball rolling plant. The melting capacity at this works comprised of one 10-ton and two 5-ton arc furnaces.

In subsequent years further expansion took place at the Union Junction Works, with the installation of additional arc furnaces and ball forging and casting machines. In March, 1951, the company commenced production on a limited range of rolled sections, from a 12-in. merchant bar mill. With further extensions in melting capacity more mills were installed in 1956. In addition to its foundry activities, also including electrically melted alloy cast irons and cast and forged

TABLE IV
Direct Arc Melting Furnaces

Location	No.	Size	KVA		Tons per year: Molten metal	Finished production castings	Possible production from remaining capacity
Ball and iron	4	3-ton	1000		50,000		
melting shop,	1	6-ton	2000		20,000		
Union Junction				Total	70,000	4000	57,000 (Grinding balls)
Steel melting	1	3-ton	1200		9000		
shop,	1	6-ton	2000		17,000		
Union Junction	1	10-ton	4000		27,000		
				Total	53,000	15,000	27,000 (Ingots)
Steel melting	2	5-ton	1500		26,000		
shop,	1	10-ton	3600		22,000		
Driehoek				Total	48,000	2500	43,000 (Ingots)
				Grand Total	171,000	21,500	127,000

Rolling mills	Billets	Sections
Union Junction Works		
One 5-stand cross country type 3-high, 12-in. mill	12,000	11,000
One 18-in. 3-high cogging mill, 5-stand cross country type 3-high	34,000	...
One 5-stand cross country type 3-high 12-in. finishing mill	...	30,000
Total	46,000	41,000

grinding balls, this firm is rolling rounds of mild and low alloy steels and a range of light angles and flats. Present capacity, in short tons per annum, is given in Table IV.

GEO STOTT

Another company that started rolling operations as a direct result of mining activity, was Geo Stott & Co., engineers and blacksmiths. They installed a 12-in. mill near the Wemmer gold mine in 1921 for rolling scrapped ore stamping battery stems and axles into merchant bars. Later a 2-ton shingling hammer was built for the purpose of fagotting blooms from scrap steel. Additional equipment was obtained over the years, especially after Iscor came into existence, thereby making billets available for rerolling. This plant is presently rolling about 12,000 tons of light sections per annum and the installation of electric arc furnaces for steelmaking is contemplated.

Discussion

PRESENTED BY

W. W. POWELL, Vice President, Mesta Machine Co., Pittsburgh, Pa.

J. R. FERGUSON, JR., Assistant Vice President, Design & Construction-Engineering Dept., United States Steel Corp., Pittsburgh, Pa.

JOHN A. MOLLOY, Vice President, The Armco International Corp., Middletown, Ohio

F. H. WUETIG, Manager, Fred H. Wuetig and Associates, Chicago, Ill.

G. A. ZAHAROFF, American Representative, Demag, Pittsburgh, Pa.

DR. C. M. KRUGER, General Manager, South African Iron and Steel Industrial Corp., Ltd., Pretoria, South Africa

W. W. Powell: The establishment of the Vanderbijlpark Works and its growth represent a most interesting development. In 1942 the South African Iron and Steel Corp. purchased 37,000 acres of land 35 miles south of Johannesburg. The site was typical South African veldt sparsely populated by nonwhite native families living in huts and kraals. During the second world war Iscor erected a 110-in. plate mill on the property, but before they could establish the staff for the operation of this unit, they had to build a hotel, a general store and limited housing facilities. The demand for flat rolled steel products at the close of World War II continued in sufficient volume to justify plans to proceed with the building of the completely integrated steel plant that Dr. Kruger has described in detail.

Land was provided for an industrial area to be sold to manufacturing industries using the product of their mills. Terms and conditions were offered to attract such industries, and today there are many factories in operation adjacent to the Vanderbijlpark Works. Railroad, cars, gold mining equipment, locomotive parts, cranes, steel castings, forgings and many other items are manufactured. There is a large can factory in production there, and the fabrication of the building steel required for South African construction is done at Vanderbijlpark.

Vanderbijlpark is situated virtually on the Tropic of Capricorn with a latitude equivalent to Florida or Mexico. However, the weather is generally cool on account of the high elevation almost 5000 feet. The rainfall is sparse, and while the Vaal River is only a few miles away water must be conserved. It is recirculated throughout the plant and plans are being made for even the sewage effluent to be purified and this water used for cooling. The housekeeping is probably the best in the world. The employees are dressed in white, even in the steelmaking and rolling mill departments. The management of Iscor is of the highest order. The supervision of the plant is in the hands of highly skilled trained personnel. Non-whites are used for general labor. The policy of cleanliness, is, without a doubt, reflected in the excellent maintenance of the machinery.

The demand for flat rolled products is so great in the area adjacent to the plant that very little of their product goes to the sea coast 400 to 1000 miles away, and the latter is supplied largely from American sources. The other steel plants of South Africa are comparatively small in relation to Iscor.

J. R. Ferguson, Jr.: It has been my impression that at the time steel works were constructed in South Africa, there were no pools of skilled labor from which steel workers could be drawn. No doubt much hard work and novel solutions were required to develop a working force to operate the steel plants.

The last ten years have seen the development of several pneumatic processes for the manufacture of steel. Of these processes, the rotary oxygen is perhaps the least known and the least tried. The two kilns under construction at Pretoria and Vanderbijlpark will, we believe, be the third and fourth rotary furnaces installed in the world, the first two having been built at the Oberhausen Works in Germany where the process was developed.

Iscor has 90 per cent of the steelmaking capacity in South Africa. Competition is furnished by the small independent companies, producing primarily specialty products in plants that are not fully integrated and from steel imports from abroad. Dr. Kruger points with pride to the fact that Iscor's prices have increased only 120 per cent from the prewar period, whereas those in the United Kingdom and the United States have risen 270 and 165 per cent, respectively. No doubt the ability to minimize price increases has in a large measure been due to the technical progress achieved in the postwar period. Another factor which may be significant is that the government as the principal shareholder is content to receive only 4 per cent on its investment. Have the effects of the low price and the low rate of return been deterrents to private investors entering the industry on a major scale? From Dr. Kruger's comments on the availability of raw materials, it would seem that only investment (assuming the labor supply is adequate) prevents the expansion of the steel industry in South Africa to the point where it can satisfy domestic needs, as well as becoming an exporter to its steel-short neighbors.

John A. Molloy: In answer to the first question. Iscor started as a small company of 180,000 ingot tons

capacity. When they placed their orders for equipment in Europe, the European manufacturers of the equipment arranged for quite a few Iscor engineers to be trained in Europe for the period from 1930 to 1934 when the plant started.

In addition, Iscor had American and European operating personnel there to help them get started. As a matter of fact, there were still some German steelmaking men in South Africa when World War II came on. They had a period of years to train their organization.

When they moved forward to the strip mill, they had quite a few of their personnel trained in the U. S.

We agree with Mr. Powell that they had many capable operators and engineers at the higher supervisory level.

Now as to the question on the rotor process versus the LD, Dr. Kruger will have to answer that. All we know is that they had nearly decided to put in the LD process when they investigated the rotor and made their decision to change.

The other question, has somewhat of a political nature because of the fact that the state owns Iscor. I think that Iscor has succeeded—they have kept their prices down certainly because the state has been willing to have a low return and pass the price savings on to the industries of South Africa. The other implication is, that Iscor has been successful because it has been operated as a private company with no government interference politically. Iscor has gone through times when both of the parties of South Africa have been in power. It is my understanding that there has been no political pressure on them to do things from a political standpoint. Presumably at some time or under different management or in some other country politics could enter into one of these mixed companies and difficulties would ensue.

F. H. Wuetig: We have been associated with several foreign jobs and find that it is usually hard for Americans to understand that some countries do not have sufficient private capital to invest in one particular industry, so that it is necessary for these industries to get the bulk of their capital from the government.

Another thing that is difficult for Americans to understand is why the industries in these countries do not keep up with the demand. This is due to a demand that is growing faster than their industry can supply, and private investors cannot provide capital at the rate that is required to expand the industry.

American companies have sponsored or furnished technical assistance to many of these enterprises. Most of these developments are mixed government and private capital arrangements. This is the only way that they can keep up in a small country where limited capital is available.

G. A. Zaharoff: The rotor furnace plant is so designed that all operating experience and possible methods can be employed. The rotor furnace is a cylindrical vessel, about 15 meters long and 4.5 meters in diameter, with both ends open. It rotates around its longitudinal axis at speeds variable from 0.2 to 4 rpm. The oxygen needed arrives in two separate lines (primary and secondary oxygen). The primary oxygen is blown in through a water-cooled nozzle below the surface of the metal bath and the secondary oxygen is blown in over the bath surface. The flue gases forming during this are drawn off through the opposite opening.

The hot metal is tapped through one of the tapping holes in the vessel into a steel casting ladle suspended from a crane.

The furnace is equipped with two interchangeable vessels, which is an essential and decisive factor for an economical operation (Figure 9).

The furnace foundation below floor contains a turntable which allows the vessel to take any required position within the 360 degree full-circle range. The turntable carries two trestles with equalizers to support the furnace cradle with the vessel (Figure 10). Also a variable electro-hydraulic tilting drive is located on the turntable. This allows to tilt the cradle with the vessel up to a vertical position (90 degrees) for vessel exchange purposes and to carry out all motions necessary for pouring out the hot metal.

The rotation drive is mounted on a platform attached to the furnace cradle.

When the vessel requires relining the furnace cradle is tilted up to a vertical position and the now vertical vessel is withdrawn from the cradle on an electrically operated carriage and the relined vessel is subsequently moved in. This minimizes the furnace downtimes at the end of a furnace campaign. After the vessel is tilted back on its cradle to a horizontal position the furnace is at once ready again for operation.

As both end openings of the vessel are equal, operation from both ends is possible. This contributes to longer life of the vessel lining.

By means of the turntable the vessel can be turned to have its opening before anyone of the auxiliary installations. The furnace platform carries the lance handling device, with primary and secondary nozzles, which is firmly connected with the cradle to follow in all furnace motions. Thus it is possible, when the lining is partly burned out, to tilt the vessel slightly towards its blowing end to achieve there an increased depth of the metal bath. This leads to increased life of the lining.

The furnace platform carries also a burner which keeps the vessel at temperature during the downtimes. Opposite this burner and the lance handling device there are water-cooled flue gas lines which lead the flue gases off through an incorporated dust extraction plant.

In addition there is a cover mounting device on the furnace platform to enable one of the vessel ends to be closed by an imposed cover. This ensures that the inside temperature remains constant when the vessel is tilted up high.

The complete equipment of the furnace installation includes also a charging machine, which travels on the furnace platform, and a movable launder.

The two vessels are lined in a vertical position and are burned out by means of a burner. The flue gases are led off into the open air through the stacks positioned in the bay structure.

A 15-ton crane installed in the central bay is used for repair work and other work in connection with the relining of the vessels.

The whole rotor furnace plant with all its metering and regulating systems is controlled from a desk mounted on the furnace platform. Safety and interlocking devices avoid any mutual interference of operations and ensure a perfect order of work.

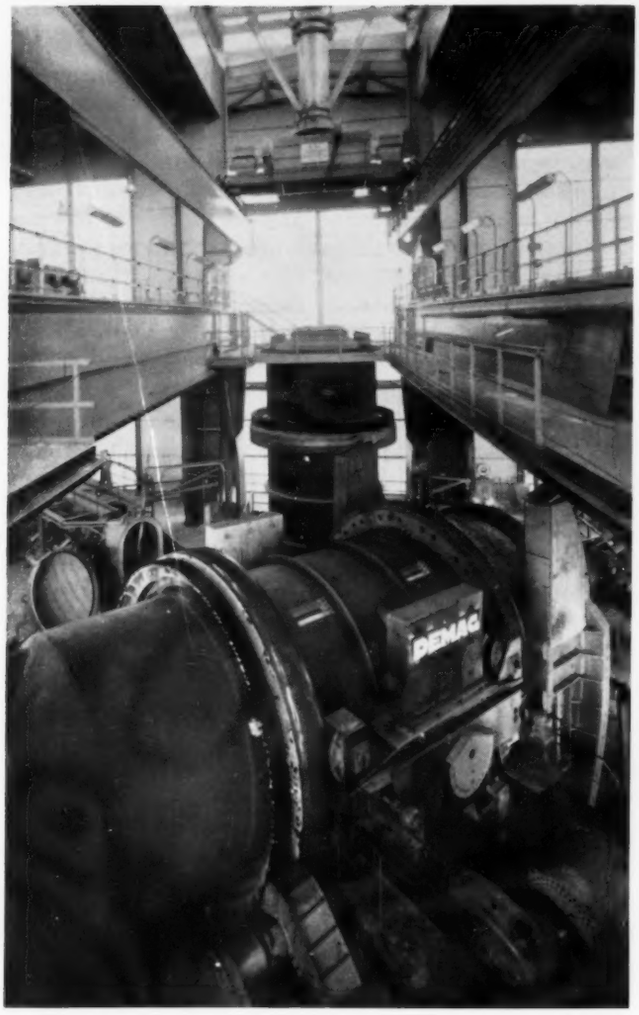


Figure 9 — Two interchangeable vessels are essential for economical operation of the rotor unit.

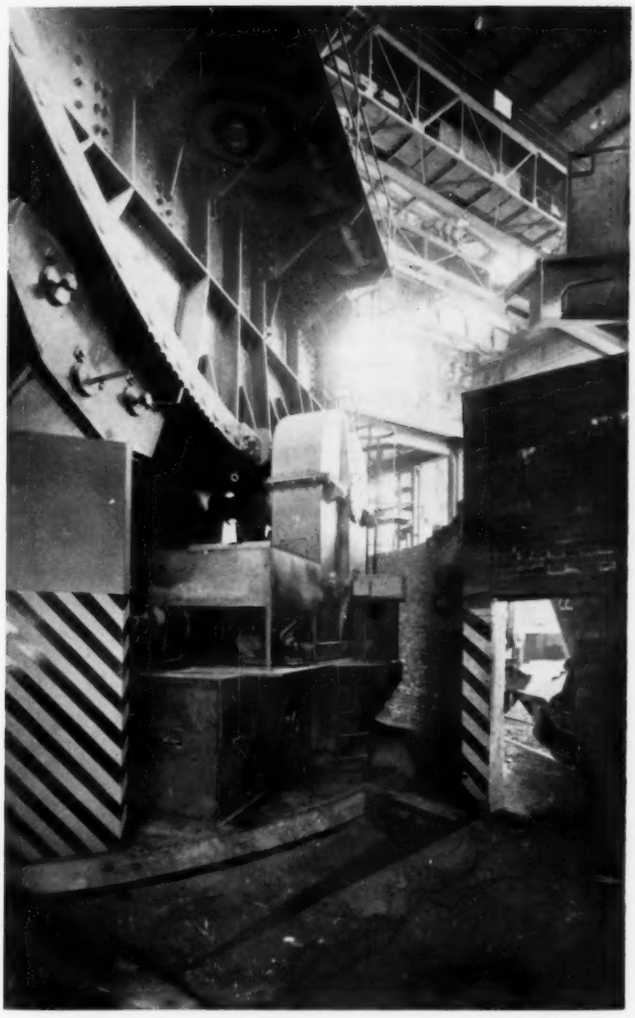


Figure 10 — The turntable and cradle permit locating the vessel in any position desired.

Dr. C. M. Kruger: In reply to Mr. Ferguson's question, we may add that to compensate for the absence of generations of background in iron and steelmaking, Iscor has found it necessary to employ perhaps a larger percentage of academically trained personnel than have steelworks in the older countries. As Mr. Molloy has indicated, technical and operating personnel have also from time to time had advance training in overseas steelworks. Relatively large groups were sent to Germany and England before starting up the Pretoria Works and to the U. S. before starting up the Vanderbijlpark Works.

Fortunately South Africa is well endowed with universities and other training centers of high repute and even in the postwar period we have experienced no greater shortage of trained personnel than, e.g., the U. S. Regarding operatives, it has been our experience that lads from the predominantly rural communities have proved to be adaptable and keen. They have become capable industrial operatives, artisans and foremen after only a few years experience in heavy industry. In addition, Iscor has established a department for education and training which has assisted materially in overcoming shortages of trained labor. On the other hand, although the nonwhite employees are gradually becoming more adept in industry, their very high rate of turnover still limits them to jobs requiring limited skill and experience.

In reply to Mr. Ferguson's second question, the reasons for Iscor selecting the rotor in preference to other pneumatic methods of steelmaking are as follows:

1. At the time that the corporation had to decide on a process to increase its ingot output, no other method contemplated vessels of 100-ton capacity. The pilot rotor at Oberhausen was at that time making heats of 60-metric tons.
2. At that same time the LD was using up to 30 per cent scrap for cooling. There is a shortage of scrap in South Africa and the possibility of using iron ore was, and is, attractive, as the units of iron thus gained are at a lower cost than the iron produced by the blast furnace.
3. The LD process requires oxygen of a purity of not less than 99.5 per cent. The rotor process can, and is, using oxygen of 95 per cent and less purity, and is still making steel with nitrogen contents of 0.004 per cent and less. The cost of making oxygen increases rapidly when a purity of over 95 per cent is required.
4. A better ingot yield from the molten iron input to ingot is expected from the rotor process, than other pneumatic methods.
5. While it was not an over riding consideration, it

was considered at the time that the fumes from the rotor plants would be easier to handle than in the case of the LD.

The corporation put into operation its rotor plant at Iscor Works, Vanderbijlpark, on November 15, 1959. To date (January, 1960) some 32,000 tons of ingots have been made. Difficulties with linings have been experienced but this was expected, and trials are being carried out with various types of basic refractories and different variations in the operation, such as volumes of oxygen, velocity of oxygen, concentration of the secondary oxygen, weight of ore added and other items.

We can state definitely, however, that the steel produced is at least equal to the best basic open hearth quality and that the oxygen consumption is appreciably lower than was expected.

In regard to the other points mentioned above, we would not like to pass comment at this stage because, after all, our operating experience is still very limited and we have not yet settled down to routine production.

In reply to Mr. Ferguson's final question I would like to amplify Mr. Wuetig's comments. Dividend policy in regard to the state shareholding is essentially that of reimbursing the government with the cost to them of the capital invested in Iscor. In consequence this dividend has been at the rate of 6 per cent since 1956. Taxation is that of any other private company. The actual amount of the dividend, e.g. (£1 1/2 million in 1959) has only limited significance, as Iscor is able to reserve upwards of four times this amount per annum towards financing of expansion.

This aspect of ability to finance expansion out of earnings is important in a country such as South Africa, with a fast-expanding economy and a consequent heavy demand on capital resources.

With regard to Iscor's apparent inability to keep up with the rising demand, it is a fact that South Africa's industrial expansion in the postwar period has exceeded our expectations. The curve showing Iscor's production, Figure 5, will, however, show a very sharp rise in 1960/61 when the current expansion scheme is completed. ▲

Available Translations

As a service to readers of the *Iron and Steel Engineer* a list of translations from foreign articles is being printed intermittently. Articles selected for this listing will be those of primary interest to the American steel plant operator. The papers may be obtained from the British Iron and Steel Industry Translation Service, The Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W. 1, England. All correspondence concerning price, ordering, and so forth should be directed to that address.

1424 SHAPOVALOV, M. A.: "Oxygen in Blast Furnace Smelting," *Kislorod*, 1958 (4), pp. 1–11 (Abstract J.I.S.I., 1959, May, p. 86b) Trials at Novo Tula with oxygen-enriched blast are described. Up to 25 per cent enrichment is used for smelting conversion irons and up to 26 per cent for foundry irons. Furnace productivity was raised by 3.5–4 per cent for each per cent of oxygen above 21 per cent. The coke rate remained constant. Up to 31 per cent oxygen blast was used for smelting ferro-alloys. Productivity was raised by 80–90 per cent when smelting FeMn and by 53 per cent for FeSi. Coke rate dropped by 15 per cent. Some economic factors are discussed. When a reducing gas is blown into the hearth simultaneously with the use of oxygen-enriched blast, there is a marked reduction in the coke rate.

1466 GRINBERG, S. A.: "Production of Tubes With Internal Plastic Coating," *Stal'*, 1958, Nov., pp. 1018–1020. (Author's summary.) The process for manufacturing plastic-lined tubes (by means of polymerized welding—without drawing), developed at our works, makes it possible to replace the costly alloyed steel tubes by these plastic-lined tubes in a number of branches of industry, in which corrosive fluids are conveyed.

1433 DRILLER, A.: "The development of Arc Steelmaking Furnaces and of Electrode Control Mechanism," *Elektrotechn. Z.*, 1956, Feb. 21, pp. 41–47. (Author's summary: The growing demand for electric furnace steel is leading to the construction of new arc furnaces with a capacity of up to 120 tons and ratings up to 36,000 kva. New automatic electrode control mechanisms have been developed, namely, hydraulic, e.g., with plunger control mechanisms, and electromechanical with rotating regulator generators and magnetic amplifiers.)

1449 KALTENECKER, H.: "How Can Theory Help The Control Engineer?" *Gas u. Wasserfach*, 1959 July 3, pp. 681-687. (Abstract preprinted from J.I.S.I.: An attempt is made to translate the concepts and equations of theoretical control processes into practical and descriptive terms. The transfer function, frequency response and stability are considered in this way and the practical application of these concepts, statistical methods, and the use of the analog computer are outlined.)

1456 BROVMAN, M. Ya.: "Deformation of the Work Material in Cross Rolling," *Stal'*, Rolling and Tube Manufacture Supplement, 1959, 22–33. (Abstract preprinted from J.I.S.I.: A method of calculation is presented and a condition for critical reduction producing axial cavity-formation is developed. The values are close to those obtained by Smirnov's method and also correspond with measured values.)

Sandwich Rolling

Large thin gage sheets of special steels can be produced to accurate tolerances on present mills through the use of sandwich rolling techniques.

by H. S. ORR
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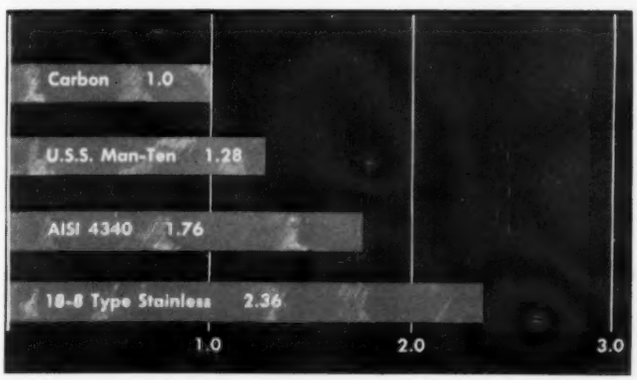
IN recent years, the needs of the aircraft and missile industries have established a trend toward higher strength materials and temperature resistant materials which have design capabilities beyond the traditional construction metals. These industries require a full complement of mill commodities; the most important raw material commodity required is sheet. Axiomatically, very large sheet product permits better design. The need for large sheets is generated by the resulting reduced structure weight, through the elimination of joints and the realization of greater structural reliability.

The problem of manufacturing sheets of larger dimension for aircraft and missiles is greatly aggravated by the type of alloys required. Temperature resistant materials such as Rene 41 for honeycomb facings, the H-11 type die steels as well as constructional alloy steels for structural applications in solid propellant motor cases and the higher chromium martensitic and precipitation hardening stainless steels typify the grades having the most design attractiveness. These materials because of their superior elevated temperature strengths resist deformation in hot rolling to a greater extent than do carbon steels. In addition, many of the compositions have restrictive rolling temperature ranges which are established by their high temperature metallurgical character. Another characteristic sometimes found with these steels is their hot shortness or disposition toward edge cracking and surface deterioration on rolling. These factors impose limitations on rolling mill capabilities which are not encountered when rolling carbon steel.

Another requirement of the designers of our nation's weapons is close control of thickness, in terms of both nominal gage and of crown on sheet products. Better control of gage is beneficial both from the standpoint of weight control on finished parts and assemblies and from the standpoint of weight reduction if sheet products can be held as close as possible to the theoretical design section thickness. Benefits are also realized if the manufacturer can control, reduce or eliminate mechanical property directionality. Improved surface quality on sheet materials affects savings in fabricating by reducing surface conditioning costs. Surface condition may also have a direct bearing on the aerodynamic

Figure 1 — Relative power requirements for reduction of the four steel grades show that the available power of the mill will greatly limit the product size which can be rolled.



qualities of the finished product. Another essential requirement of the aircraft and missile industry for alloy and stainless sheet products, particularly in the martensitic steels, is the minimization of decarburization, since it directly affects the resulting mechanical properties.

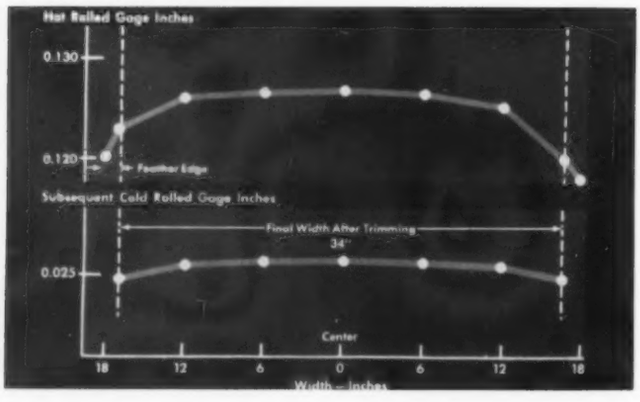
Rolling mills designed primarily to roll carbon steels, frequently are not adequately powered to convert the alloy and stainless grades from slab to sheet in the full width and thickness ranges of their carbon steel capabilities. Figure 1 graphically compares the relative power requirement for a given unit reduction in section associated with carbon steels, a typical high strength composition—USS Man-Ten, a typical alloy composition—AISI 4340, and a typical austenitic stainless grade—Type 304. The power available to a mill such as the 80-in. hot strip mill at Gary Sheet and Tin of the United States Steel Corp. imposes limits on width and thickness in the production of special steels—each mill having its own limits. To illustrate this point, such a piece of equipment is capable of making carbon steel sheet in hot rolled gages as light as 0.090 in. and in widths as great as 72 in. For the production of USS Man-Ten in the 0.090 in. gage, this mill cannot normally exceed 54 in. in width. Similarly, 4340 could be produced in gages no lighter than about 0.135 in. and widths not exceeding approximately 48 in. and the 18-8 type 304 product could be produced in gages no lighter than about 0.150 in. in widths up to approximately 48 in. Where combination of gage or width for a grade exceed these power capabilities, the successful manufacture of the item would involve the use of more powerful rolling mills or a different manufacturing method.

Figure 2 demonstrates the distribution of crown throughout the width of continuously rolled strip. The top curve illustrates the contour of the strip as hot rolled, and the bottom curve, the contour of the same strip after cold rolling from the hot rolled strip gage of 0.125 in. to a cold rolled gage of 0.025 in. It is interesting to note that the element of crown generated in hot rolling can be numerically reduced by cold rolling. However, as a ratio of the thickness, crown is not significantly affected by cold rolling. The per cent of crown remains relatively constant from the hot rolled strip to the final cold rolled thickness.

Contours are developed on rolls to counteract the effect of roll deflection and therefore, minimize the crown on the resulting product.

Normally, slabs for rerolling are heated in furnaces

Figure 2 — Crown as a ratio of thickness is not noticeably reduced by cold reduction.



exposed to an atmosphere composed of air and the combustion products of the heating gases. It is not practical to heat slabs in a controlled atmosphere in the conventional carbon slab reheat furnaces. This is because of the volume of material which must be handled and the flow rate of material through such a furnace is so great as to prevent achievement of a stable controlled atmosphere. Because of this, hot rolled sheets, especially the higher carbon martensitic alloy and stainless materials, are not produced with the surfaces totally free of decarburization. However, by careful slab heating and controlling the amount of reduction from slab to finished product, decarburization can be greatly minimized.

From the foregoing it is obvious that the producer must exercise the best known controls and ingenuity in producing highest quality alloy and stainless products for critical aircraft and missile applications. Beyond this, it should be recognized that there are basic limitations in manufacturing equipment used in producing sheet products which result in unavoidable characteristics of the end products.

The needed steel production capability to satisfy the numerous demands of the aireraft and missile industries can be realized only by expanding the methods and technology of conventional manufacturing practices or by the use of novel methods of manufacturing.

The United States Steel Corp. has responded to these demands by investigating the feasibility of both methods of achieving the end product. Engineering studies have been completed which define the facilities needed to accomplish the objectives by what might be called conventional sheet rolling equipment. The corporation has also expended a large amount of effort in the examination of novel methods of sheet manufacture which might bring about desired end results. The most promising of these novel methods of sheet manufacture is a process which has been titled "Sandwich Rolling." Sometime ago the corporation prepared and rolled approximately 100 sandwich assemblies on its 80-in. hot strip mill at the Gary Sheet and Tin Mill.

The method was studied as a means of producing thin hot rolled strip of difficult to roll stainless and alloy steel compositions. Such light gage hot rolled strip presents a distinct advantage in the subsequent cold rolling of the very light gages of stainless and alloy steel.

In answer to the aircraft and missile industries' requests mentioned earlier, the potentials of the sandwich rolling method came under re-examination late in 1957. Most of the work since then has been conducted on the 160-in. plate mill at Homestead District Works of the corporation. This mill was used in the developmental work because it offers the greatest width potential of any of the flat product mills.

Sandwich rolling is well-described by its name, for the process begins with the construction of a "sandwich" of several plates which have been rolled by conventional methods. A typical sandwich consists of two heavy gage carbon steel plates with a filling of several stainless or alloy steel plates, placed between them (Figure 3). Both the carbon steel cover plates and the alloy or stainless filler plates are thoroughly cleaned by grit blasting and treated with a stable oxide compound which prevents pressure welding during subsequent hot

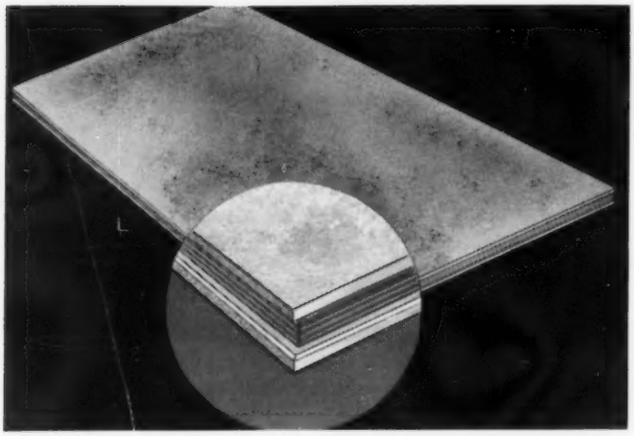


Figure 3 — A sandwich section consisting of two carbon steel cover plates and several alloy filler plates is illustrated.

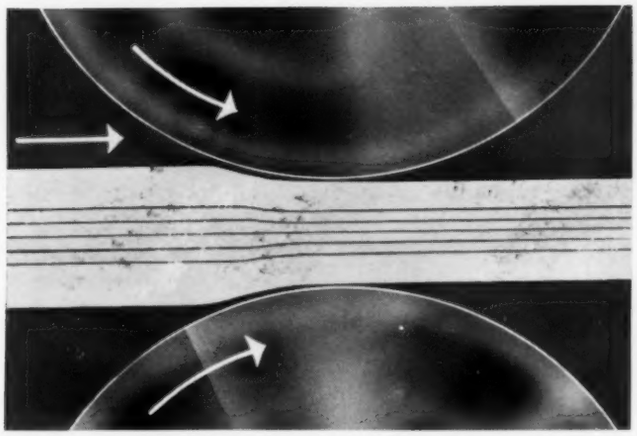


Figure 4 — Reduction of each item is proportional to the over-all reduction of the sandwich.

rolling. The sides and ends of the sandwich are welded closed with flat bars of carbon steel. The fabricated slab is then heated and rolled on a hot strip or plate mill in much the same manner that a conventional slab is rolled. During rolling each component of the fabricated slab is reduced in proportion to the over-all reduction in thickness of the complete assembly (Figure 4).

After rolling, the sandwich assembly is heat treated or annealed and then flattened. Annealing the composite assembly is one of the advantages of the process, if constructional alloy steel is involved, since the material on the inside of the assembly is annealed while enclosed in an airtight carbon steel envelope, thereby eliminating the need for controlled atmosphere furnaces.

The edges of the sandwich are then sheared off and the sheets separated from each other. The sheets are then resquared, identified, coated and boxed for shipment. Figure 5 is an example of finished sheets.

It is important to note that sandwich rolling is done entirely on existing conventional flat-rolled product manufacturing equipment, and that the process is within the capability of this equipment. Yet the product of sandwich rolling is far wider and thinner than any which can be obtained by conventional sheet manufacturing methods or equipment today. Sandwich rolling enables existing hot strip mills and plate mills to supply materials hitherto unavailable because the process removes many of the limitations imposed by conventional rolling practices.

As was shown in Figure 1, the power required to roll alloy and stainless steels is much greater than carbon steel. Power requirements are also a function of thickness, increasing in geometric proportion as the thickness decreases. This is shown in Figure 6. By virtue of the carbon steel cover plates and the aggregate thickness, it is obvious from Figure 6 that the rolling mill power requirements are much less for the sandwich assembly than for any of the components rolled separately.

The use of the side bars, which are subsequently removed, eliminates a substantial element of crown associated with the edges of hot rolled product.

Rolling on wide plate mills affords the opportunity of cross rolling which minimizes mechanical property directionality and further reduces crown.

Because of the protection afforded by the carbon steel envelope during heating for rolling and subsequent heat treatment, the product of this process has improved surface. Edge and surface cracking on difficult to roll grades is practically eliminated. Decarburization is so slight that it is difficult to detect by normal hardness differences or microscopic methods of measurements.

The Homestead Works of United States Steel Corp. has rolled about 350 sandwich assemblies on its 160-in. plate mill, producing in excess of 2500 sheets. Figure 7 illustrates the size ranges in which the corporation has confidence of manufacturing capability based on this experience. United States Steel Corp. has rolled 120-in. wide AISI Type 4340 as thin as 0.040 in.; USS Airsteel X200 up to 140 in. wide, 0.090 in. thick; 133-in. wide PH15-7 Mo as thin as 0.020 in. and 96-in. wide H-11 type hot work die steel from 0.050 in. to 0.187 in. thick. The thickness tolerances which can be guaranteed on

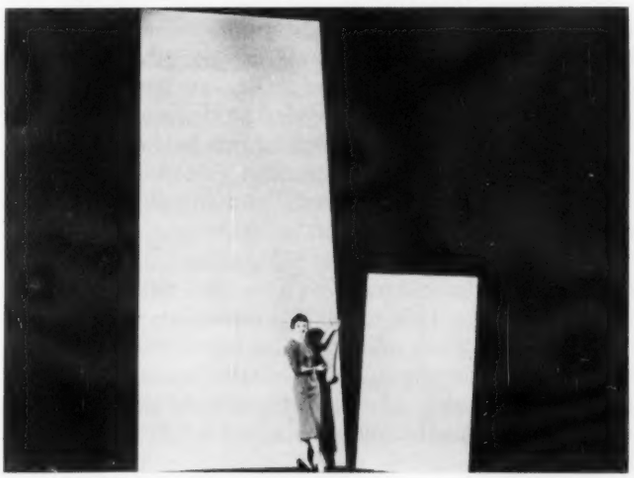
TABLE I

Established Gage and Gage Tolerance Capability. Sandwich Rolled Sheets

Gage in in.	Tolerances in in. Width, 48 to 84 in. inclusive	Width, over 84 to 140 in.
0.030 to 0.037 inclusive	±0.003	±0.004
0.0371 to 0.078 inclusive	±0.004	±0.005
0.0781 to 0.141 inclusive	±0.005	±0.006
0.1411 to 0.187 inclusive	±0.006	±0.007

Capability for gages down to 0.005-in. thickness is anticipated and is under current development.

Figure 5 — The illustration emphasizes the availability of the large sizes produced by sandwich rolling.



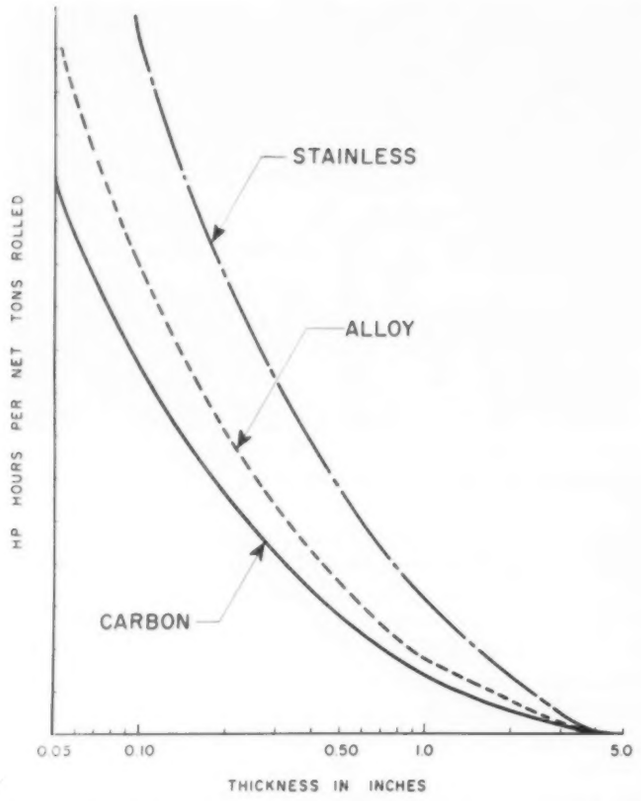


Figure 6 — Relative power requirements illustrate that the mill power necessary to roll a thick section is much less than for the thinner sections.

Gauge	Tolerances 48" to 84" Inclusive Width	Tolerances Over 84" to 140" Width
.030 to .037 Inclusive	± .003"	± .004"
.037 to .078 Inclusive	± .004"	± .005"
.078 to .141 Inclusive	± .005"	± .006"
.141 to .187 Inclusive	± .006"	± .007"

Capability for gauges down to .005 thickness anticipated and is under current development.

Figure 7 — Widths up to 140 in. are available in some materials with gage tolerances less than one-half of standard tolerances.

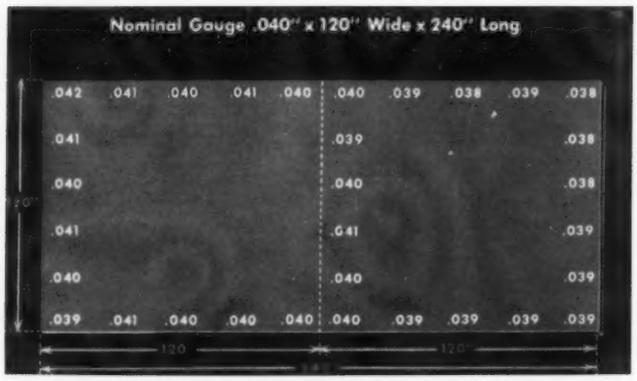


Figure 8 — Gage measurement checks on a 120-in. wide AISI 4330 sheet show that the thickness variation is within the gage tolerance.

such sheets are those shown in Figure 7, which are approximately one-half of standard tolerance for conventional sheets of half the width.

As could be expected from any normal distribution curve, many sheets have thickness variations well inside the table of limits shown. Near optimum gage performance is seen in Figure 8 on a sheet of constructional alloy steel ordered 0.040 x 120 x 240 in.

Extremes of gage beyond those shown in Figure 7 have been produced experimentally by sandwich rolling and are still under current development.

A substantial amount of material has been produced in a wide variety of grades. See Table II. These include constructional alloy grades, austenitic stainless grades, martensitic stainless grades, semiaustenitic precipitation hardenable stainless grades and nickel base super alloy grades.

The process has potentialities to produce taper rolled sheets with tapers throughout their length and width. Several trials have been conducted on a laboratory mill which indicates the feasibility of producing such sheets on large mills. Additional work on this particular feature is required and could be pursued if a need develops.

It is felt that some of the difficult to roll temperature resistant nickel base materials can be produced in strip form suitable for subsequent cold rolling for honeycomb foil stock. United States Steel's research and technology department has this under consideration and has already programmed rolling trials. In addition, much of the present experimental effort on the process is directed at the production of stainless and nickel-base type materials in the thickness range of 0.005 to 0.020 in. in order to establish manufacturing capabilities for wide very light gage sheets suitable for honeycomb face plates.

In conclusion, the known measurable improvement in sheet products which have been demonstrated or can reasonably be expected from the sandwich rolling process are listed below. Keep in mind that these advantages are obtained by a novel method of rolling on conventional equipment. In addition, large, wide, light gage

TABLE II

Grades of Steel Rolled to Wide, Light Gage Sheets by the Sandwich Rolling Method.

Grades	
USS Airsteel X200 AISI 4335 AISI 4340 INCO 300-M MBMC No. 1 MBMC No. 2 AISI 4130 LADISH D-9 MXP-2	Alloy grades
TYPE 304 TYPE 309 TYPE 316 TYPE 347	Austenitic stainless grades
H-11 Type die steels USS 12 MO-V TYPE 410	Martensitic stainless grades
USS Stainless W 17-7 PH PH 15-7 MO	Semi-austenitic precipitation hardenable stainless grades
M-252 Haynes Alloy No. 25 Rene 41 A-286	Nickel base super alloy grades produced and contemplated

sheets were made available to the industry several years earlier than would have been accomplished by the building of new facilities.

1. Large sheet size availability.
2. Closer gage control.
3. Minimization or elimination of crown.
4. Minimization or elimination of decarburization.
5. Improved hot rolled sheet surface.
6. Reduced mechanical property directionality through cross rolling.
7. Production of small quantities for prototype requirements.
8. Potential of contour or taper rolling.
9. Reduces sensitivity to edge and surface cracking on grades normally difficult to roll.
10. Potential method for producing hot band in grades where conventional strip production is not feasible.

Discussion

PRESENTED BY

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L. H. Such: The demand for these large light gage sheets should be measured by their necessity rather than the immediate volume potential.

The international competition in the missile and aircraft fields is obvious, and our position can be successfully held only by providing designers with materials they request, both in physical properties and physical dimensions.

As shown, the ability to produce these difficult to roll alloys in large widths and lengths or even in greatly reduced thicknesses is only half the battle. The uniformity of the thickness within a piece and from piece to piece require precise control of many factors.

The authors have shown that they have recognized these factors and have attacked the problem with a great deal of ingenuity.

We at Allegheny Ludlum can fully appreciate the problems involved since we also have done a little work along these lines and have contributed to the complexity of the problem by introducing some of the recognized super alloys.

We would like to ask a few questions of the authors:

1. Is there an optimum number of core pieces you like to work with, say five or seven, or is this strictly a function of the size of the end product.

2. On the Gary Mill; how much thinner were you able to roll a sandwich coil than the limit mentioned of 48 x 0.150 in. of solid 18-8? Also, in the core material of a sandwich coil, what kind of end-to-end gage variation did you find in one of the core layers?

3. You mention the preparation of the sandwich components, the cleaning, treatment with stabile oxides and the complete welding. Do you introduce a partial pressure of an inert gas or do you evacuate? Is this a necessity?

4. Since there is less power required to roll a sandwich assembly than for any of the components rolled separately, do you (a) utilize this advantage to obtain a thinner end product, (b) take less passes in your schedule, or (c) use a lower furnace temperature?

E. C. Smith: My problem is to give this audience some idea of the respect for those corporations that tackle a defense requirement in spite of the fact that the possibility of profit may be doubtful. Certainly, within our years in the steel industry, neither profit nor gratitude can be assured when military necessity calls. Economic limitations are seldom understood by those in political power. These limitations, as far as can be determined, are not even considered by the usual employees of metal working companies. Another handicap is that military men not understanding our problems think that loud threatening talk is the only element essential to success.

My first experience was as a civilian during the years 1917 to 1919 with the Signal Corps of the U. S. Army, where I was given the job of getting unusual steel products for the construction of the aircraft of World War I. This was supplemented by the experiences from 1941 to 1945 and finally by the affairs since the Korean incident.

Without enumerating detailed incidents, a few examples will explain my viewpoint.

During the depression days of the early 1930's, the aircraft industry found a need for thin stainless steel. As a member of the Material Subcommittee of the then National Advisory Committee for Aeronautics I was requested to approach Dr. R. E. Zimmerman, of U. S. Steel Corp. and ask for the aid of his company. After the facts were presented to Dr. Zimmerman, the subsequent agreement resulted in the experiment of rolling thin wide structural stainless steel on the mills at the Gary plant. Equipment not being suitable for the task, considerable damage was done before it became evident that some new mechanical device was required.

The experiment with the German cluster mill also ended with unsatisfactory results. These hard stainless steels simply wreck good mills of conventional design.

Both experiments, costly as they were, went to completion at a time when the steel industry was being portrayed to the nation as "Merchants of Death." The experience gained in these experiments was certainly the basis of much of the production of structural stainless steels for the Navy and Air Force in World War II.

This present accomplishment stems from Defense

Department requests for wider, higher strength aircraft construction sheets. The Materials Advisory Board, of the National Academy of Sciences, discussed these requests for some years. Only those steel plants with the big wide strip and plate mills could consider the work.

The estimates of the cost involved in providing a mill that could roll single stainless sheets 100 in. wide, 600 in. long, in thicknesses less than 0.100 in. indicated that another plan was necessary. Sandwich rolling was the answer.

There is one problem that is a serious obstacle to progress. The firm that is really trying to fill the need expects to lose $250,000 before it fills the first order amounting to approximately one ounce of finished material. It is difficult to understand the abuse the public gives the industry of our country during a time as critical as this.

We need better communication with the poeple of our land. We must evolve some plan to have our position understood. This is not a nation which gets results by compulsion. Nor do we advocate imprisonment or death as the motivating force in industry. We want no part of Lenin's "Sudden and Severe Punishment" the reward he promised to engineers who make mistakes. We and the corporations, with which we as engineers are associated, need to be considered as a real part of this country.

J. C. Bomberger: Mention of the power requirements for materials with considerable strength at elevated temperatures points out an area where information is still needed, particularly for newer alloys. Referring to Figure 1, it is hoped that the power needs for the rolling of materials such as the nickel base high temperature alloys will eventually be indexed to carbon steel as well as to a common stainless type such as Type 302. Probably some of the alloys cited will be even more difficult to roll as far as power is concerned than Type 302 stainless steel.

We agree with the authors that the power requirements for rolling are also a function of thickness, increasing in geometric proportion as the thickness decreases.

Rolling mill power requirements are less for the sandwich assembly than for any of the components rolled separately, as would be concluded from the graph of Figure 1. Dealing with the problem in terms of power requirements is the likely way to think of it when hot rolling solid single sheets in a sheet mill, where heat losses increase rapidly as the gage decreases until the situation is comparable to cold rolling rather than hot rolling. The same problem could also be stated in terms of higher rolling temperatures prevailing in the heavier gage composite assembly than for a single insert component of much lighter gage, so that deformation is much easier to accomplish at higher temperature levels.

The use of side bars, which are subsequently removed, is stated to eliminate a substantial element of crown associated with the edges of hot rolled product. We believe this effect would be relatively more important for narrow sheet of less than 48 in. width. It is felt that the effectiveness of side bars in reducing crown becomes insignificant as rolled width increases toward the maximum limits possible in large plate mills.

Future data may serve to show users the degree of directional uniformity in mechanical properties attainable through the cross-rolling feature of the process as practiced on large plate mills.

It is agreed with the authors that due to the protection offered by the carbon steel envelope, decarburization is so slight as to be negligible by ordinary standards of hardness and microscopic measurement.

As to gage and gage tolerance capability, work conducted at Lukens on the sandwich rolling process leads to a comparatively simple pattern for classifying gage tolerances without regard for width.

Sheet gage, in.	Tolerance, in.
Under 0.070	±0.005
0.071 to 0.125	±0.006
Over 0.125	±0.007

While these tolerances appear to be liberal, nearly all sandwich rolled sheets will lie well within the tolerances given. They apply not only to the individual sheets, but also to sheet from the same rolled assembly as well as to sheet from various assemblies.

Among the best gage results produced so far at Lukens are a number of sheets ranging up to 160 in. wide x 320 in. long that have shown gage uniformity with ±0.002 in. as measured over the entire area on a grid of 24-in. centers. Sheets with as little as ±0.001-in. variation in gage were produced in 150 in. width in rare cases under nearly ideal conditions.

The ability to attain the desired nominal gage with extremely tight tolerances in gage variation depends, among other things, on plate material of superior gage uniformity for use in assembling the sandwich structure. Excellent gage results also depend on a knowledge of the deformation characteristics of the alloy materials being hot rolled into sheet form. In Figure 4, each component of the sandwich assembly will reduce in proportion to the over-all reduction in thickness of the complete assembly provided that the cover plates and the filler or insert material of the "sandwich" have very similar behavior during hot rolling.

We are also interested in whether grinding or chemmilling of the sheet leads to any type of metallurgical damage. If so, it would be of interest to know what steps can be taken by the user to repair the damage and restore the sheet to prime condition for fabrication.

L. Moses: A recent metallurgical article calls vivid attention to the serious difficulties of missile fabrication from customarily sized sheets. The supply of 10 x 20 ft patterns is a very real contribution.

Can the authors comment upon the allowable flatness tolerance of the filler sheets in the fabricated slab as well as width and length tolerance? Thickness variations in lengths sheared from extreme front and back ends of strip must be an important feature in obtaining the uniform finished sheet gages described.

It is understandable that widely varying conditions stemming from finished gages and characteristics of materials dictate the number of sheets in a slab. However, could this be covered more fully?

Is there difficulty with weld disruption as might be caused by internal pressure of heated gases in the fabricated steel?

The curve on Figure 1, showing relative power

requirement to hot roll the respective compositions, is a valuable contribution to the literature on rolling.

W. L. Keene: A question arises—what is the relationship between the thickness of the oxide coating and the permissible amount of reduction in the hot mill; that is, is there a limiting reduction which must not be exceeded else sticking would occur? The reason for this question is that some years ago we attempted to use this sandwich system (somewhat modified) on a hot strip mill with rather embarrassing results. Our reduction from assembled composite billet to hot rolled strip was of the order of 32 to 1, i.e., from 4 in. thick slab to $\frac{1}{8}$ in. thick strip. Our separating compound thinned out to such an extent that we obtained a rather good mechanical bond and could not separate the layers of strip.

Later on, we assembled a sandwich of copper on a hot rolled, not descaled steel slab and hot rolled it in a strip mill. We again obtained a good bond between the two albeit the appearance of an Erichsen dome was somewhat lumpy, due to the islands of scale present at the interface. We would be inclined to believe that reductions in a plate mill would not even approach those obtained in a strip mill, but would like to know what reductions have been used successfully in this "sandwich process."

Another statement in the paper reads: "During rolling each component of the fabricated slab is reduced in proportion to the over all reduction in thickness of the complete assembly." To make this statement true, we assume that the authors are disregarding the outer carbon steel cover plates and are concerned with only the inner alloy plates which would necessarily be of the same composition each with the other. Our experience in cladding through many years has taught us that every metal or alloy has a certain individual plasticity or resistance to deformation at a selected temperature and there can be quite a spread in properties between, for example, nickel and copper, heated to the same temperature, which causes them to reduce during hot rolling at different rates, especially when unbonded to each other, as is the case at the start of rolling (and of course in a "sandwich.") When we bond copper to steel, we allow for a greater thinning of the copper—when we bond nickel to steel, we allow for a greater thinning of the steel and calculations are made before assembling the components of the slab so that final percentages of each metal will be in accordance with specifications.

In sandwich rolling, as described by the authors, I would doubt that this problem arises very often, although the contingency may arise. In such case, differently behaving components might be assembled in the same sandwich.

Does the separating compound used prevent carbon migration between the carbon steel cover plates and the inner alloy layers during annealing? Perhaps the question has not yet arisen, considering the nature of the alloys that have been so far rolled but it could. For example, if one were to construct a sandwich assembly consisting of low carbon steel and Type 430 stainless steel, with nothing between the inner faces, then roll bond the assembly, then batch anneal for the usual cycle, even though the carbon content of the steel and the 430 are each 0.10 per cent, carbon will migrate from the steel to the stainless and collect at the interface in a layer which analyzes 0.40 per cent carbon. This layer, after certain heat treatments, becomes quite hard and brittle and causes "flaking" of the stainless away from the steel base. We have not found that "stable oxide separating compounds" are effective in preventing carbon migration and wonder if the authors have run into this particular problem.

H. S. Orr and F. R. Romeo: Commercial flatness tolerance is acceptable flatness for the filler plates although we prefer something better. The length and width tolerance on the filler plates is $\frac{1}{4}$ in.

For ordinary sheet gages (0.040 to 0.100 in.) we normally use four plates of hard-to-roll material with two carbon cover plates. More inner plates have been used and the rolling of a well heated assembly, composed of six, eight or more layers, causes little difficulty. However, a practical limitation on the number of inner components is the problem of heating. The heating time required increases directly with the number of layers in the assembly. We also visualize shearing difficulties if the rolled assembly exceeds 1 to $1\frac{1}{2}$ in. in thickness.

All assemblies are vented to relieve internal pressure of heated gases. By sandwich rolling on continuous mills, stainless grades such as 18-8 can be produced in gages of 0.010 in. without difficulty. End-to-end gage variation is on the order of 2 per cent which in turn is a function of end-to-end gage variation of the entire assembly.

We have done a little experimental work with evacuation and purging with an inert gas. This does not appear to be necessary except possibly on certain stainless and super alloy grades.

One of the principal advantages of sandwich rolling is the ability to roll thinner end product. The number of passes required to obtain a given finished gage is far less when rolling a laminated slab than if the same finished gage was made in single ply. The heat loss on the inner layers is extremely low compared with rolling the same steels single ply; therefore lower furnace temperatures are the rule.

Thickness of the oxide coating alone will not prevent pressure welding even on relatively light reductions. Temperature, grade of steel, type of coating, surface preparation, and especially how uniformly the coating spreads over the enlarged surface area are more important factors in preventing pressure welding.

The separating compounds currently being used do not prevent carbon migration between the carbon steel cover plates and the inner layers.

Rolling reductions and temperatures are calculated on the basis of the composition and rolling characteristics of the inner components.

With respect to the use of side bars and their effect on crown, we find that if there is a crown effect on a sheet, it will be seen generally on the narrower sheets. This is opposite of the effect believed by Lukens. However, there is little, if any, crown effect on sandwich rolled product regardless of width.

Although Lukens indicates a more simple pattern for classifying gage tolerances without regards for width, their tolerances are more liberal than our own.

There has been no evidence which indicates that grinding or chem-milling of sandwich rolled sheets leads to any metallurgical damage. ▲

Application of Individual Drive Motors To Live Mill Tables

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Individually driven mill table rolls permit rapid reversal, reduce mill downtime and eliminate the lubrication systems and preventive maintenance required on lineshaft drive tables. The large number of units involved also bring up the question as to whether the AISE Motor Committee should not set standards for these motors.

THROUGHOUT the whole process of reducing, shaping or working of steel, as well as other nonferrous metals, the bulk of the material handling is accomplished by roller tables. Each set of tables, whether they be furnace delivery tables for slabs, hot strip mill runout tables, or rod mill cooling bed tables, must be considered differently as to application of electrical equipment. In most cases generalities cannot be made. Each type of table will need to be analyzed on the basis of its own requirements, so that the electrical equipment selected will provide optimum performance at lowest cost.

This paper covers the application of individually driven live tables on reversing hot mills. Although blooming, slabbing, plate or reversing roughing mills have differences in the type products rolled and means of operation, the live roller tables for each of these mills are similar in almost all respects so that generalities in applying electrical equipments can be made. Requirements for all live table rolls are identical, in that during the complete rolling cycle, the hot steel is transported to the mill and reversed during each rolling pass. These tables are subjected to high temperatures, heavy loads and high impacts due to quick and frequent reversals, and to shock loading by the product.

The first installation utilizing individually driven live tables was made in 1954. Prior to this installation, table rolls were driven in sets through a line shaft and miter or bevel gear drive. Since then, the majority of new mills installed have been furnished with individually driven rolls and, in a number of instances, line shaft drives for existing mills have been replaced by individual roll drives. A list of installations is included in Table I.

ADVANTAGES

It is felt by most mill builders that an increasing number of new installations will utilize the individual roll drives because of the success of the early installations, and because of the over-all advantages over the line shaft drive. There are a number of reasons to substantiate this trend.

1. The live tables are subject to severe impact loads and are required to reverse rapidly during each pass. Consequently, the gearing must handle high peak torques. The inherent problem of backlash causes excessive wear of the gears. Although overload capacity is built into the gears, the impact and peak loads imposed do damage mechanical parts, increase tooth wear and even break the gear teeth. With the demand for higher reversal speeds, the costs and difficulties of constructing the gearing with these demanding requirements have increased. Based on this, the individual motor drive concept offers the mill builder and user definite advantages, since the gearing and its associated design and construction is eliminated.

2. The driving of each roll by an individual motor virtually eliminates the possibility of an unscheduled shutdown that might be associated with the lineshaft drive. The mechanical construction of directly coupling the motors to the table rolls can withstand the heavy duty shock loads better than the miter gears. In addition, the failure of one drive or roll would not shut down the mill, while the lineshaft mechanical failure or even the failure of one drive motor would require a very costly shutdown.

3. Although the unscheduled downtime caused by a mechanical breakdown is the most critical expense, the breakage costs and the maintenance of the gearing is a

substantial expense. The actual cost of maintaining the lineshaft drive can vary from mill to mill, depending on the method of evaluating the costs, but it is obvious that the time spent repairing or replacing the gearing on the lineshaft drive would be much higher than individually driven rolls. One mill had estimated that approximately $70,000 to $80,000 a year, not including labor, was spent on just the oil for the line shaft drives. After converting to individually driven rolls this expense was virtually eliminated.

MOTORS

Due to the lack of gearing between the table rolls and the drive motor, the motor is required to run at a speed considerably lower than the base speed of a standard 230-volt motor. If a standard 230-volt motor was applied, it would have to be run in most cases at much lower than 100 volts. The cost of providing a low voltage generator and its associated control would in almost all cases be prohibitive.

To enable the use of higher voltages within the range of the heavy duty mill auxiliary 250-volt generator, slow speed motor ratings were developed in the AISE 600 frame sizes. The construction features include many of the features of the MD-600 auxiliary mill type motor and utilize as many of the components used to supply the AISE standardized ratings as possible. A list of the ratings are shown in Table II.

There are two basic ratings in each AISE frame size that have been used to meet application requirements. The "A" ratings have been established by modifying the AISE standard 550-volt design. This provides a

TABLE I
Installations of Individual Mill Table Rolls

		Application	Quantity	Frame	Rating Design
1.	McLouth Steel Corp., Trenton, Michigan (Universal rougher 60-in. hot strip mill)	Approach table	26	MD-608-AEL	A
		Front table	25	MD-608-AEL	A
		Back table	25	MD-608-AEL	A
		Finish mill Approach	70	MD-606-AEL	A
2.	Bethlehem Steel Co., Sparrows Point, Md. (160-in. plate mill)	Approach tables	16	MD-610-AEL	A
		Front tables	15	MD-610-AEL	A
		Front feed rolls	2	MD-610-AEL	A
		Back feed rolls	2	MD-610-AEL	A
		Back table	15	MD-610-AEL	A
		Runout table	30	MD-608-AEL	A
3.	McLouth Steel Corp., Trenton, Michigan (40-in. blooming and slabbing mill)	Front table	11	MD-614-AEL	B
		Back table	11	MD-614-AEL	B
4.	Columbia-Geneva Steel Div., U. S. Steel Corp., Geneva, Utah (45 x 115-in. universal slabbing mill)	Front table	14	MD-618-AEL	B
		Front feed rolls	2	MD-618-AEL	B
		Back feed rolls	2	MD-618-AEL	B
		Back table	14	MD-618-AEL	B
5.	Bethlehem Steel Co., Sparrows Point, Md. (45 x 90-in. universal slabbing mill)	Front table (mill end rollers)	4	MD-616-AEL	B
		Edger feed rolls	2	MD-616-AEL	B
		Front feed rolls	2	MD-616-AEL	B
		Back feed rolls	2	MD-616-AEL	B
		Back table (mill end rollers)	4	MD-616-AEL	B
6.	Jones and Laughlin Steel Corp., Cleveland Works Div. (reversing rougher 77-in. hot strip mill)	Approach tables	20	MD-608-AEL	A
		Front tables	15	MD-610-AEL	A
		Edger feed rolls	4	MD-610-AEL	A
		Front feed rolls	2	MD-610-AEL	A
		Back feed rolls	2	MD-610-AEL	A
		Back table	15	MD-610-AEL	A
		Runout table	34	MD-608-AEL	A
7.	Tata Iron & Steel Co., Jamshedpur, India (46-in. blooming mill)	Front table (mill end rollers)	2	MD-618-AEL	B
		Front feed rolls	2	MD-618-AEL	B
		Back feed rolls	2	MD-618-AEL	B
		Back table (mill end rollers)	2	MD-618-AEL	B
8.	Lukens Steel Co., Coatesville, Pa. (38 & 59 x 140-in. plate mill)	Front table	(4	MD-614-AEL	B
			(6	MD-616-AEL	B
		Front feed rolls	2	MD-616-AEL	B
		Back feed rolls	2	MD-616-AEL	B
		Back table	(6	MD-616-AEL	B
			(3	MD-614-AEL	B
		Edger front feed rolls	2	MD-614-AEL	B
		Edger back feed rolls	2	MD-614-AEL	B
9.	Inland Steel Co., East Chicago, Ind. (45 x 90-in. reversing slabbing mill)	Front table	14	MD-616-AEL	B
		Front feed rolls	2	MD-616-AEL	B
		Back feed rolls	1	MD-616-AEL	B
		Back table	14	MD-616-AEL	B
10.	U. S. Steel, South Works, Chicago, Ill. (53-34-in. structural mill)	Hot saw tables	23	MD-604-AEL	A
		Stand 1 runin table	26	MD-604-AEL	A
		Stand 1 runout table	29	MD-604-AEL	A
		Stand 2 runin table	39	MD-604-AEL	A
		Stand 2 runout table	38	MD-604-AEL	A
		Stand 3 runin table	55	MD-602-AEL	A
		Stand 3-stand 4 table	50	MD-602-AEL	A
		Stand 4 runout table	74	MD-603-AEL	A
11.	U. S. Steel Corp., Duquesne Works, Duquesne, Pa. (36-in. blooming mill)	Front table	8	MD-612-AEL	B
		Back table	8	MD-612-AEL	B
	U. S. Steel Corp., Duquesne Works, Duquene, Pa. (45-in. blooming mill)	Front table	10	MD-616-AEL	B
		Front feed rolls	2	MD-616-AEL	B
		Back feed rolls	2	MD-616-AEL	B
		Back table	10	MD-616-AEL	B
12.	Sheffield Steel Corp. (No. 2 plate mill)	Front feed rolls	2	MD-614-AE	B
		Back feed rolls	2	MD-614-AE	B

TABLE II

Slow Speed, 600 Series Shunt-Wound Motors 230-Volts, Forced Ventilated

AISE frame size	Design	Hp (cont 75 C rise)	Base speed rpm	Amps	Volts per rpm	Hot IR and brush drop, ohms	Torque in Lb at 1-ft Radius: Continuous	Maximum start	Maximum run	Approximate Wk^2 of motor, $lb\text{-}ft^2$	Ventilating Air Required: Cfm	Static Pressure in in. of water at motor inlet
602	A	2.80	313	12.5	0.545	59.4	47	177	162	4.2	160	½
603	A	3.71	295	16.0	0.599	53.4	66	258	236	7.3	200	½
604	A	5.78	272	24.0	0.673	46.5	112	420	385	11.6	250	½
	B	1.97	107	10.3	1.36	84.6	96	366	336		250	½
606	A	9.75	246	39.0	0.775	39.4	209	855	812	25	335	¾
	B	3.49	101	16.6	1.58	70.2	181	694	635		335	¾
608	A	13.5	219	54.0	0.871	39.2	324	1200	1100	45	425	¾
	B	5.15	90	24.9	1.75	72.0	300	1105	1010		425	¾
610	A	19.4	198	76.0	0.983	35.4	508	1880	1720	72	525	1
	B	7.44	84	34.3	1.97	64.8	459	1690	1550		525	1
612	A	29.2	193	112.0	1.03	31.8	782	2960	2710	123	750	1½
	B	12.5	82	56.0	2.07	60.5	785	2940	2700		750	1½
614	A	38.7	175	149.0	1.125	32.9	1160	4200	3850	209	900	1
	B	16.7	75	74.5	2.25	59.4	1160	4080	3740		900	1
616	A	58.9	172	222.0	1.17	28.2	1790	6900	6320	360	1200	1¼
	B	26.2	76	111.0	2.36	50.7	1810	6480	5940		1200	1¼
618	A	78.8	152	295.0	1.34	26.2	2730	8880	8150	580	1600	1½
	B	46.9	89	185.0	2.15	37.7	2740	9900	9080		1600	1½

minimum of components to meet the over-all requirements of the steel industry. The second rating or "B" design is a modified winding combination of the "A" design to provide approximately half speed. These two ratings in each frame size provide a flexible list of ratings for all the applications rated 230 volts. Experience over the past five years in applying individual drives to each type of hot mill indicate that the two speed ratings were sufficient to cover the different application requirements for each of these mills. By referring to Table I, it can be seen that some 800 motors have been installed utilizing the two speed rating in Table II, without a need for a further special design.

As will be pointed out later in the sample calculations, the motor will be selected on the basis of accelerating torque requirement; therefore, the maximum torque ratings listed in the table will determine the required frame size. Although the duty is of a start and stop nature, the selection will neglect RMS heating because the calculations made to determine the maximum torque reflects the worst condition, which theoretically occurs once every schedule, and the rolling torque to overcome friction and windage is a small percentage of the rated torque of the motor. Therefore the rated hp listed in Table II is of little significance, in this application, except to designate the nameplate rating of the machine.

MOUNTING AND VENTILATION

Figures 1 and 2 are photographs of a typical installation of individually driven rolls on live mill tables for a blooming and slabbing mill. The motors are flexibly coupled to the roll shaft extension and horizontally mounted to the same foundation mounting the table rollers. This provides a solid and rigid foundation which minimizes adverse wear due to vibration or impact, even though the rolls are directly coupled to the drive motor. Experience on installations that have been in operation for five years have substantiated this.

Due to the center line distance between rolls the motors are mounted in a staggered arrangement, the connection leads are brought up from the bottom through a conduit box located on the commutator end of the machine. This eliminates any inteference problem that would occur if the conduit were brought out the sides.

The motors are ventilated from a common system with air supplied through a duct into the mounting pad for the motor. The air is forced through the commutator end over the windings and exhausted out through the coupling end. The motors supplied for this application were supplied with only single shaft extensions to save space.

To overcome the space problem on another installation, the motors were mounted on both sides of the mill with the motors on the same side coupled to each alternate roll. The motors were able to be coupled closer to the rolls but two ventilation ducts had to be provided. Both the staggered arrangement and the opposite mounting installations have been successful and no definite advantages for either have been observed.

CONSIDERATIONS IN DRIVE SELECTION

There are five basic considerations that determine the selection of the required motor torque, each of which has a bearing on the rating of the drive motors and generators. These are listed as follows:

1. Table roll and drive motor inertia.
2. Time or rate of acceleration or deceleration.
3. Slab or ingot weight and maximum percentage which is required to be accelerated by one roll.
4. Roll diameter.
5. Coefficient of friction between the slab or ingot and the roll.

After assigning the relative values to the points mentioned above the calculations to determine the ratings of the motors and generators are fairly straightforward. The values of inertias and roll diameters are fixed by the design of the mill, but the values assigned for the other constants can vary as to the type of mill and the means of operation, which can cause an appreciable variation in the torque requirements of the various drives.

PERCENTAGE OF SLAB WEIGHT

The percentage of slab weight one roll must accelerate is inversely proportional to the number of rolls that are

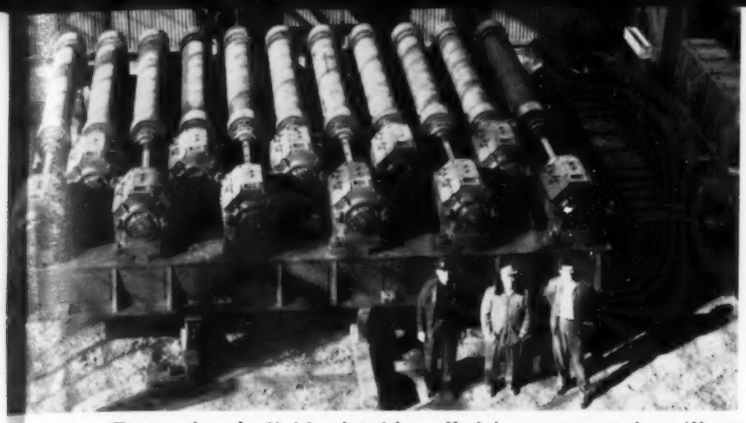


Figure 1 — Individual table roll drives mounted as illustrated have a rigid foundation which minimizes wear due to vibration and impact.

in contact with the material at the same time. The assigned value should reflect the worst condition. During this condition the minimum number of rolls are supporting the material. After each successive pass the weight would be distributed over a wider range of rolls and would consequently reduce the torque requirements on each individual motor. A conservative, but practical, assumption to make on a blooming-slabbing mill is to consider that one roll will be called on to accelerate ½ of the weight of one ingot. On the intermediate mills such as plate or reversing roughers, it should be assumed that only 70 per cent of the total number of rolls that are in apparent contact with the initial slab are accelerating this slab. This extra margin is due to the fact that some of the rolls located under a slab are not in direct contact with the slab due to bowing.

COEFFICIENT OF FRICTION

The acceleration performance of roller tables is directly related to the frictional force between the surface of the slab and rollers. An understanding of the frictional force and its relationship to the table performance is important to the selection of the electrical equipment.

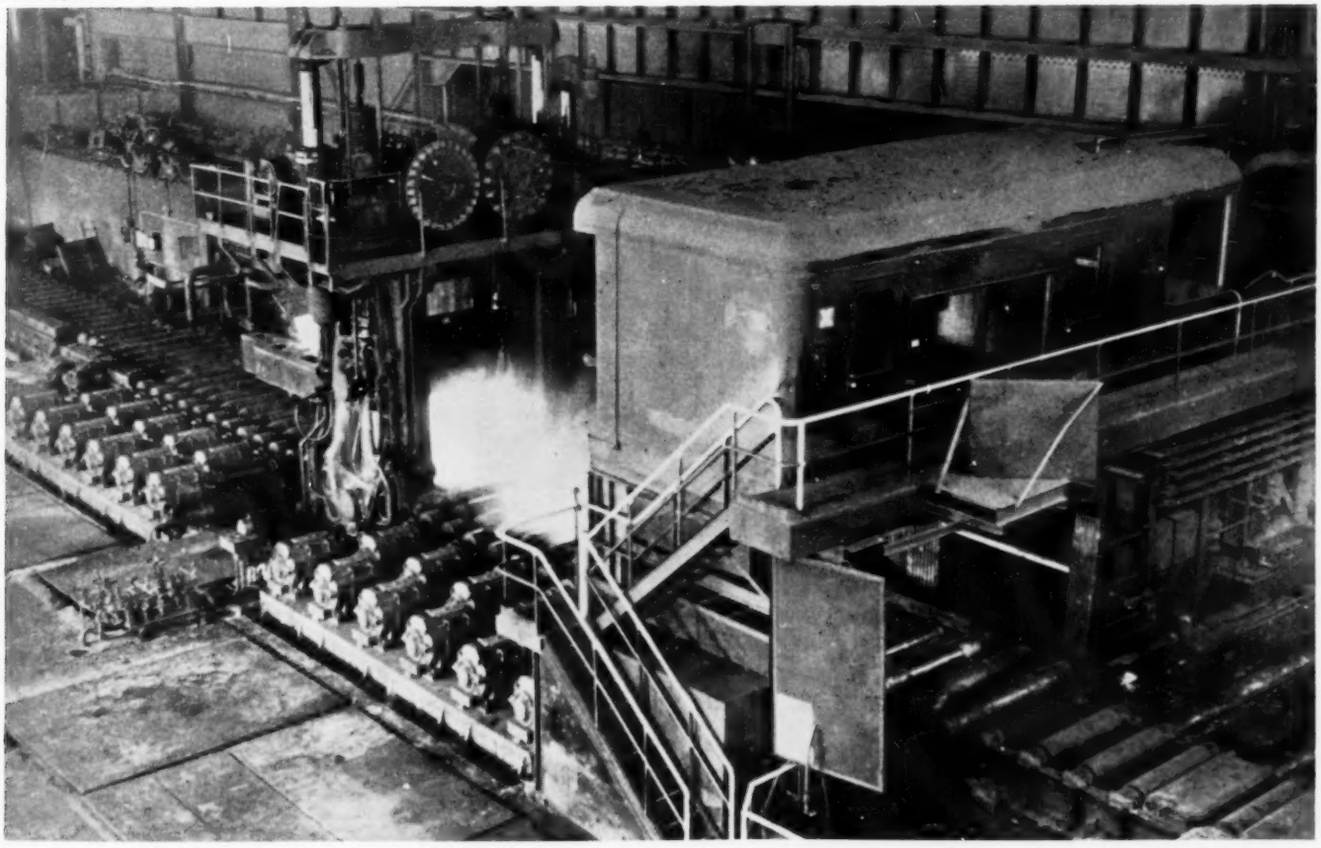
The force is equal to:

$$F = \mu W = \frac{Wa}{g}$$

where F is the force acting on the slab, μ is the effective coefficient of friction, W is the weight of the slab, a is the acceleration of the slab, and g the gravitational constant. From these equations we find that $\mu = a/g$; the slab acceleration is directly proportional to the effective coefficient of friction.

A paper prepared by S. K. Dean and M. A. Kilburn, presented to the Institute of Mechanical Engineers, London, England, and published in the December, 1955, issue of the *Engineering Digest* describes the experiments conducted and lists the results regarding the coefficient of friction between steel slabs and roller surfaces. The tests were made primarily on laboratory model roller tables. During the tests, the roller speed was held constant and a hot test slab was dropped on the table. The acceleration of the slab from rest to the speed of the rollers was measured by an accelerometer and the coefficient of friction was calculated by use of the basic formula. During the acceleration period the slip between the slab and rolls decreased from a value that equaled roller speed to zero. Values of average effective coefficient of friction covering the whole acceleration range from maximum slip to no slip were given, the mean of all the average values measured during one series of tests on clean slabs and clean rolls was equal to 0.31, while during another series it equaled 0.27. With

Figure 2 — The available torque must be enough to accelerate the slab to mill speed in the required time to permit proper mill operation.



heavily oxidized slabs, the effective coefficient of friction was about 10 per cent greater than with clean slabs, while with clean slabs and with the rollers wiped with powder, to assimilate dirty rolls, the value was 20 per cent greater.

The laboratory test results were compared by the authors, with results obtained on an actual blooming mill, by running the tables toward the mill and measuring the time it would take to decelerate and reaccelerate the bloom. The test results compared favorably with the laboratory results.

Based on the results listed in the paper, as well as the evaluation of the expected performance on past installations, it would be safe to assume that the effective coefficient of friction varies from 0.25 to 0.35.

By analyzing the accelerating requirements of a reversing hot mill, it is apparent that the range of values listed should not be the limiting factor in achieving the desired performance. As an example it is found that the slab speeds of the mills do not exceed 500 fpm at base speed. If the mill is expected to reverse from base to base in 1.5 sec, and the required time to accelerate the slab is 0.75 sec, then the coefficient of friction required would equal:

$$\mu = \frac{a}{g} = \frac{v}{tg}$$

$$\mu = \frac{500}{(0.75)\ (32.2)\ (60)} = 0.34$$

For a one sec acceleration the required coefficient of friction would need to be equal to 0.24.

This means that it is theoretically possible to accelerate the slab from zero to base speed in 0.75 sec if the average effective coefficient of friction is equal to at least 0.34. It would not be possible to accelerate in this time if the coefficient of friction is less. Similarly, trying to accelerate faster with the same coefficient would result in slippage. Based on rolling practices today, 0.75 sec seems to be the practical limit as far as acceleration or deceleration time is concerned. If a faster rate were necessary, the coefficient of friction would probably be the limiting factor.

CONTROL EQUIPMENT

To provide the primary requirements of the control, which is to produce the required acceleration and deceleration rates with a high degree of reliability, adjustable voltage control is used. The high rates can be obtained because higher average torques can be maintained with the stepless voltage regulator.

Provided the rolls do not slip under the slab, the limiting factor in the acceleration of the rolls is the machine commutating ability and the maximum starting torque. This ability is dependent on the rate of change of current, as well as peak current, and both are dependent upon the rate of voltage change. The regulator controls the rate of voltage build-up and decay which in turn regulates the acceleration rate of the rolls. This rate can be set during installation to a value equal to the maximum allowable limits, obtaining the fastest acceleration rate of the rolls.

The motors are protected against extreme overloads by an instantaneous overcurrent relay set at the maximum permissible current rating of the motor. Upon tripping, the overcurrent relay is reset automatically, but by interlocking the motor with a voltage relay, the motor is prevented from reaccelerating until the table has been brought to a normal stop.

In addition, the motors can be protected against high RMS loads by thermal devices mounted in the commutating pole coils. In most cases this protection is provided for the rolls nearest the mill, which would be subject to the severest loads and reversals. The device would be set to trip at a maximum safe temperature of the motor and can also be used as an indication that a motor has been tripped. As a further refinement, a second thermal device can be used as a warning and pick up at a lower temperature.

MOTOR AND GENERATOR SELECTION

The following is a sample calculation made to select the motors and generators for the tables of a typical blooming-slabbing mill.

Mill Data

Weight of ingot = 18 tons
Main drive motor
base speed = 40 rpm.
top speed = 100 rpm.
Reversal time of mill
base to base = 2 sec
top to top = 7 sec
Diameter of table roll—20 in. (solid)
Length of roll—115 in.
Diameter of mill roll—46 in.
Number of rolls back or front mill table section—14

Inertias

WK^2 of table roll (20 x 115 in.) (Table III)
30.79 x 115 = 3450 lb-ft²
WK^2 of ingot
$WK^2 = W \times r^2$
36,000 $[10/12]^2$ = 25,100 lb-ft²
WK^2 of motor (Assume a MD-616) = 360 lb-ft²
Total WK^2 of motor and roll = 3450 + 360 = 3810 lb-ft²
Assume total to equal = 4000 lb-ft² including couplings, etc.

TABLE III
Wk^2 of Solid Steel Cylinder 1-In. Long

Diameter in in.	Wk^2, lb-ft²
6	0.2494
7	0.46217
8	0.78814
9	1.262
10	1.924
11	2.818
12	3.991
13	3.497
14	7.395
15	9.745
16	12.61
17	16.67
18	20.21
19	25.08
20	30.79
21	37.43
22	45.09
23	53.87

Based on steel at 487 lb per cu ft.
Moving decimal point one place in diameter shifts decimal point four places in same direction in wk^2.
For cylinders longer or shorter than 1 in., multiply wk^2 from table by actual cylinder length in in.

Acceleration Time and Coefficient of Friction

With the required time for the mill to reverse equal to two sec, the acceleration or deceleration time of the table rolls should equal one sec to match the mill acceleration.

$$\text{V (at base speed)} = 40 \text{ rpm} \times \frac{(\pi)\ (46)}{12}$$

$$\text{(mill delivery speed)} = 482 \text{ fpm}$$

In order to accelerate the slab in one sec, the coefficient of friction should be equal to:

$$U = \frac{V}{gt} = \frac{482}{(32.2)\ (1)\ (60)} = 0.25$$

This value is within the range of frictional coefficient mentioned earlier as being normal for a hot steel slab on rollers.

Accelerating Torque

$$T = WK^2 N/308 \times t$$

$$\text{Speed of roll } N = \frac{(482)\ (12)}{(20)\ (\pi)} = 92.5 \text{ rpm}$$

Torque to accelerate one-half ingot (it is assumed that the worst case occurs when the ingot rests on two rolls).

$$T = \frac{25{,}100}{2} \times \frac{(92.5)}{308 \times 1} = 3780 \text{ lb-ft}$$

Torque to accelerate motor and roll

$$\frac{(4000)\ (92.5)}{(308)\ (1)} = 1200 \text{ lb-ft}$$

Total torque

$3780 + 1200 = 4980$ lb-ft approximately 5000 lb-ft

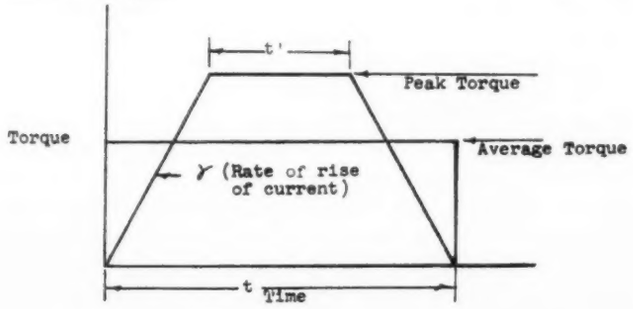
This value of torque is the average accelerating torque and is not to be considered the maximum or peak torque. A trapezoidal torque versus time curve is assumed (Figure 3) in order to obtain an approximate peak value of torque. The MD616 is to be considered for this application.

Rated torque = 1810 lb-ft
Maximum running torque = 5940 lb-ft
Maximum starting torque = 6480
Rated speed = 76 rpm

The average accelerating torque = 5000 lb-ft/1810 = 275 per cent.

A rate of rise of current (γ) of 20 per unit per sec is selected, based on past adjustable voltage applications.

Figure 3 — A torque curve is assumed in obtaining peak value of torque.



By equating the area under the trapezoid with that under average torque, the following formula is developed.

T = average accelerating torque
γ = rate of rise of current = 20 per unit per sec

$$\text{Time } t' = \left[t^2 - \frac{4tT}{\gamma}\right]^{1/2}$$

$$= 1 - \left[\frac{(4)\ (1)\ (2.75)}{20}\right]^{1/2}$$

$$= 0.67$$

$$\text{Maximum torque} = T' = \gamma\ \frac{(t - t')}{2}$$

$$= 20\ \frac{(1 - 0.67)}{2}$$

$$= 330 \text{ per cent}$$

Torque = 1810 × 3.30 = approximately 5950 lb-ft

This value is within the maximum torque rating of the MD616 motor.

The motor is rated 1810 lb-ft at 111 amp. Neglecting armature saturation and reaction, which becomes quite noticeable at high peak currents, current is proportional to torque. A 10 per cent margin in current will be added to this value to allow for armature reaction.

If the slab is considered to be accelerated by two rolls, while the 12 other motors of the section are accelerating the rolls, and if the ratio of peak to average torque is considered, the current rating will be equal to:

Peak current to accelerate the slab with two motors:

$$\frac{6000 \text{ lb-ft}}{1810 \text{ lb-ft}} \times 111 \text{ amp} \times 2 \text{ motors} = 730 \text{ amp}$$

Peak current to accelerate the 12 other rolls:

$$\frac{1200}{1810} \times \frac{330 \text{ per cent}}{270 \text{ per cent}} \times 111 \times 12 = 1080$$

Total = 1080 + 730 = 1810

Allowing 10 per cent for armature reaction the total equals approximately 2000 amp to be supplied by the generators.

Two generators would be selected for each section, by connecting each alternate roll to one generator the table will still be able to operate on a limited basis if one generator is down. The peak current on one generator will be equal to 2000/2 or 1000 amp.

The heavy duty mill auxiliary generator will have the following commutation limits:

250 per cent current at 250 volts
200 per cent current at 450 volts
0 current at 500 volts

In most cases the blooming or slabbing mill does not need to be synchronized with the mill, and the required top speed of the table may vary from 150 to 200 per cent of base speed of the mill. In this case it is assumed that the top speed is to equal 200 per cent.

Generator voltage at no load and 200 per cent speed of the mill will equal

$$\text{Generator volts} = \text{v/rpm} \times \text{rpm}$$

$$2.36 \times 97 \times 2 = 460 \text{ volts}$$

This is within the voltage rating of 250/500 volts generator.

It had been determined previously that each generator is required to develop a peak current of 1000 amp for a one-sec acceleration from zero to base speed. The peak will be developed between zero and 300 volts and a conservative commutating limit of 200 per cent on the generator is assumed. therefore:

$$100 \text{ per cent rating of generator} = \frac{1000}{2} = 500 \text{ amp}$$

At 250 volts the kw rating is equal to 500 x 250 or 125 kw.

Two standard rated 150-kw, 250-volt generator would be selected.

Based on the required rate of acceleration of one sec, a MD616, 26.2-hp, 76-rpm, 230-volt motor was selected to drive each roll, and two 150-kw, 250-volt generators suitable for double voltage operation were selected to power all 14 motors on one live table section.

If the tables were required to accelerate in 0.75 sec, a MD618 motor would probably be required. Enough torque would be available at the motor shaft to be able to slip the rolls under a slab with a coefficient of friction of approximately 0.4.

Since this mill was a blooming-slabbing mill and no direct synchronization between mill and table was required. it was possible to select a "B" design machine.

In a similar manner, if the mill was a plate or reversing rougher, the tables in most cases would be synchronized with the mill, in addition the table roll diameters would be smaller which would require a higher table roll rpm. In this case, the "A" design would be selected rather than "B." If the "B" design were used, the generator voltage would be greater than 500 volts, but by utilizing design "A," with a lower volts/rpm, the generator voltage would be less than 500 volts; even if the tables were to be synchronized with a mill motor having a 3 to 1 field range.

By utilizing the "A" design a higher rated generator would be required, because the rated amp for the "A" design is twice that of the "B." This does not mean that the generator rating will be doubled, since the peak accelerating currents will occur at a lower voltage and the commutating limits of the generator would be increased.

The generators were selected on the basis of the current requirements of the system utilizing the diversity that is inherent in the system. If the generator were selected on basis of matching the motor rating, then the size on the generation would be larger and costlier. To enable the electrical supplier to select the most economical rating of the generation, it is imperative that the mill data listed in the sample calculation be made available to the electrical supplier.

Before replacing the line shaft drive with individual motors it should be recognized that a total of more connected motor torque will be required, as an example in a recent revamp four MD614, 100-hp, 485-rpm motors were replaced by 24-MD614, 16.7-hp, 75-rpm motors. In this installation as in almost all other replacements, the existing generator ratings were utilized without any reduction in performance.

The replacement will also require new motor line panels with the associated protective equipment for each motor and possible revamping or replacing of the generator voltage regulator.

By closer examination it becomes apparent that the job of revamping the tables is relatively simple. No foundation or rearrangement of motor-generator sets is necessary. The new motor line panel can be supplied on self-supporting bases and the new table section with motors mounted on a common foundation can be constructed and placed into service without a lengthy downtime.

SUMMARY

The over-all advantages of the individually driven table over the line shaft drive have been proven by the success of past installations. The scheme has been winning the acceptance of users and it is felt that trend of supplying individual drives will continue into the future to where they will be supplied on all mills. Although the major impetus at this time is to supply individual drives to the tables withstanding the severest duty; such as feed rolls and the front and back mill live tables, it will be found that in the future the approach or furnace delivery tables will be supplied with individual drives. Experience has shown on installations that have been converted to individual drives, that the savings made in maintenance cost and downtime, have justified the cost in making the conversion.

Discussion

PRESENTED BY

H. H. ANGEL, Electrical Engineer, Construction Engineering Dept., Bethlehem Steel Co., Bethlehem, Pa.

D. R. DEYOUNG, Supervisory Engineer, Systems Control Engineering Dept., Westinghouse Electric Corp., Buffalo, N. Y.

A. JAKIMOVICH, Metal Rolling and Processing Engineering, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

I. N. TULL, Electrical Superintendent, Cleveland District, Republic Steel Corp., Cleveland, Ohio

M. W. KITZMILLER, Manager, Medium Direct Current Motor and Generator Product Engineering, Direct Current Motor and Generator Div., General Electric Co., Erie, Pa.

J. F. REIS, Electrical Engineer, Jones & Laughlin Steel Corp., Cleveland, Ohio

H. H. Angel: The subject and application of individual motor drives for live tables in reversing roughing mills has aroused a considerable amount of interest among designers, operating and maintenance personnel. The first cost of this equipment is higher than that for lineshaft driven rollers, but from what little investigating we have been able to do, it has apparently been justified in reduced delays and maintenance.

The 4-high 160-in. plate mill in the Sparrows Point Plant has 76 individually driven rollers, and the 45 x 90-in. slabbing mill has 14. There has been some difficulty in the tripping of the thermal portion of the protective breakers of some of the motors on the plate mill due to bent or bowed slabs and thus fewer table motors are actually working to accelerate the product. The author has pointed out in his paper that on these

intermediate mills only about 70 per cent of the rollers apparently in contact with the product should be figured in the calculations. It was necessary to cut out the thermal portion of these breakers. There has not been any trouble with the slabbing mill equipment. Both applications are considered satisfactory as we have not had any motor or generator difficulties.

D. R. DeYoung: What system of generator voltage rate control was applied to these individual roll table drives?

If a current limit system was used measuring the current the system draws, was it generator current limit or was it individual motor current limit?

We have found it desirable to current limit in most cases on an individual motor basis, particularly on blooming and slabbing mills. We believe this to be necessary as many times a heavy ingot will rest on one or two rolls only, thereby, making generator current limit or voltage rate ineffective in controlling the current of the few heavily loaded machines out of a group of six, seven or more motors.

A. Jakimovich: The rate regulator is a standard voltage rate regulator. We have a rotating regulator exciter for the generator field with a preamplifier consisting of two magnetic amplifiers connected in push-pull. During acceleration and deceleration the reference fields of the amplifier have a signal imposed on them that is sufficient to saturate the amplifier. The rate of change of voltage is then controlled by voltage rate feedback.

We have provided on occasions current limit on each individual motor working on generator voltage. An additional current limit is provided measuring the total generator current. As of late we are providing current limit on the tables nearest the mill, those that are receiving the severest duty. It has to be recognized that individual motor current limit still works on generator voltage, and when one motor receives an excessive peak load the whole table will slow down. On intermediate mills some operating personnel have disconnected all individual current limit, relying on the individual overcurrent relay to trip the motor off the line. In this case the tables will not be slowed down and sufficient rolls will be in contact to accelerate and decelerate the slab. This will not be true on blooming mills when the ingot or slab will rest on only two rolls.

I. N. Tull: While we did not have the first slab table with individual roller motors in operation in the industry, we did have the first d-c runout tables in hot strip mills back in 1937. At that time we used the shovel type generator. There were no plans for regulation except the inherent field design of the generators. On that job we had on the table proper some 60 motors on each of five generators. Those motors rated about 4½ hp. The coiler motors were nine 25-hp motors on the old type coilers.

The next experience in applying this type of drive was to relieve a very serious condition on a blooming mill wherein feed rollers, one in the housing and one on the outside of the housing on each side of the mill, were geared to a single motor in each case. That is, two rolls on each side of the mill had a gear box and a motor driving a pair of rollers, with constant potential magnetic control. That mill was driven with a steam engine. With a steam engine it is not only possible but very probable that the engine will stall quite frequently in the reduction of the ingots and, of course, when the ingot stalls, it stalls on the feed roller as well as on the main rolls. The damage to the gears, couplings, bearings and gear boxes was so serious that the design was changed twice in an attempt to get them strong enough but these attempts were not successful.

Of course, some of the trouble was transmitted through the coupling into the armatures of the motors. Finally individual, directly connected motors were installed on those housing and feed rollers. This was about 1951. That solved that trouble. Those motors worked without any failure, without any damage whatsoever, more than a year before removing for cleaning and general check-up. There has been only one armature failure in all of their operating life.

Applications have expanded now to where some of the mills have got live work tables with individual driven motors giving good account of themselves. We have had one mill so equipped for some two years. The individual drives on the universal slabbing mill tables have given a very good account of themselves in confirmation of what has been described in the paper.

There are some tricks about these motors. They are a big, expensive piece of equipment to buy. When these original feed roll motors were selected, it was felt that we would have to get down to a pretty low voltage applied to standard 230-volt armatures in order to secure the low speed required. Even in the case of a 550-volt armature the voltage would have to be very low. In discussing the subject one day, it was felt that if an armature were wound with sufficient turns to run at normal speed corresponding to 1100 volts, a very low base speed could be secured at a reasonably low voltage. We rather suspect that one of these frames discussed in the paper is based on turns corresponding to 1100 volts, though the ground insulation is designed for a somewhat lower operating value.

We were a little anxious about the first four motors put in on the old blooming mill because they were high voltage armatures, with fully excited fields. If by some means they could be driven at top speed, they would be generating too high a voltage for the insulation and would fail. Those motor frames were identified with red paint, the armatures with blue. Of course, a number of armatures were painted with red paint, and the frames were also painted red. Everybody understood that indicated something special, as our standard motor frame color is gray. "Let us find out what it is before we go putting it someplace it does not belong," became a slogan to remember when changing armatures or motors. Even a single armature shaft extension has to have some of that investigation. For such service only one shaft extension is usually required, for brakes or limit switches are not necessary. As most other mill type motor applications do require double shaft extensions, the difference in standard and special is at once evident by casual glance.

With the advent of the "A" and "B" nomenclatures some other means of identifying the two base speed motors, both frames and armatures, must be used, and possibly red and blue paint can be used to advantage.

In some cases we have to synchronize work table roller surface speed with the main rolls. That is usually

in the case of special steel such as stainless where there can be no slippage allowed on account of damage to the bottom side of the slab that is being rolled. The quality control people are more than insistent on that point. So there is some problem there of a combination of synchronized table speed and main drive speed with current limit control during acceleration and deceleration.

In a screwdown where usually you have about a 4 to 1 ratio on a blooming mill, the screwdown motor armature and brakes make quite a proportion of the WR^2 that you have to accelerate. The screws themselves, and their gearing are more or less a minor part. However, when you get to the table rollers, you are going to have rollers anywhere from 48 up to 200-in. wide, with diameters from 10 to 20-in. or more, the WR^2 values range from about 95 up to 6200, while the armatures inertias would vary only from about 8 to around 600.

Each case must be carefully analyzed to properly apply the right motor, coupling and control.

M. W. Kitzmiller: These slow speed armature windings can be called an 1100-volt armature if you wish. An armature which runs at 76 rpm on 230 volts, regardless of whether you call it a 230-volt armature or an 1100-volt armature, will make twice as much voltage if it is run at double speed with full field or will make four times the voltage if run at four times speed. This is true regardless of the winding combination used to arrive at the 76 rpm on 230 volts. We have chosen in most cases to utilize the standard 550-volt armature combination with twice as many turns per armature coil as a way to do it, a matter of convenience and standardization as much as anything.

One could modify the number of slots, the number of coils per slot and the number of commutator segments, to arrive at the most optimum or ideal base speed for a specific job if necessary. As the speaker has pointed out, we have found that utilizing both the 550-volt armatures and the same cores with double the number of turns has given enough combinations and application leeway to cover the requirements of the various individual applications.

J. F. Reis: The practice of applying a single motor to each roll began some 30 years ago, notably on hot strip mill runout tables. These motors were mounted in different ways and coupled directly to the roll.

Mill auxiliary drive motors applied to heavy duty table applications through angle gear lineshaft were high in first cost, required expensive lubrication and caused much mill delay. These motors were provided with rheostatic control. This combination was later improved with variable voltage control. This reduced the operating cost, maintenance cost and enables it to meet the increasing requirements of speed matching, reversal and increased mill schedules. Further increased requirements have led to the individual motor driven roll.

It seems that the first cost is somewhat higher for the individual motor to roll application. Perhaps this comparison may be secured for comparative data. The operating cost will be less because of the elimination of lubrication for the gearing, and gearing replacements. Since the table failures will be less the mill output will be greater and the net cost to operator will be less.

The motors applied to these drives must be provided with suitable lubricants to suit the extreme cold to extreme hot conditions, the bearings must be provided with suitable seals to exclude fine iron oxide dust, mill scale particles and hot and cold spray (high pressure and flooding) water.

Since most of these individual roll drive mill auxiliary motors are force-ventilated the air intake connection at the rear of the motor, must be suitably designed to prevent infiltration of mill air and to permit easy removal and replacement. Also, the self closing flap at the air discharge port (commutator end) must properly seal the opening when the forced air system has failed or is shut down.

It is preferred that the individual motor protective panels be installed in the mill area rather than in the motor room. These panels should provide necessary control equipment and shall include a disconnect switch and suitable signal lights and bulbs. If the disconnect switch is a plastic case circuit breaker or otherwise its application must be on the basis of the motor current and the maximum internal temperature obtaining inside the enclosure, the maximum temperature in the mill building at the location of the individual protective controls may be such as to require that the enclosure be forced ventilated.

The motors listed in Table I by the author (not including strip mill hot runout tables) indicate that some 900 mill auxiliary drive motors have been applied to individual rolls at mills for tables and mill feed rolls. We would like to see representatives of the other manufacturers state the number, size, etc., of their motors so applied and specifically to what mills and steel companies. The total motors of all three manufacturers will be a measure or guide for future application.

We would ask that the Association of Iron and Steel Engineers extend the activity of the AISE Wiring Committee to revise the AISE Standard No. 8, Crane and Mill Auxiliary Drive Motor Cable & Wire Size Standards (Ref. AISE December, 1958) to cover the wire and cables recommended for motors used for individual roll drives.

A. Jakimovich: Mr. Reis is probably correct in his cost analysis in that the net cost to operate the individually driven rolls will be less than the gear driven. The overall first cost comparison should include not only the differential cost of the electrical equipment but must also consider the differential cost of the mechanical equipment in going from a geared drive to an individual drive. In replacing a geared drive with individual driven rolls or an existing mill, the saving in operational cost is the only consideration and is compared with the cost of the additional equipment.

The mill type auxiliary motor meets the strenuous requirements mentioned by Mr. Reis and is ideally suited for this application.

The physical location of the protective panels for the individual drive on the heavy duty live tables is handled on a mill-to-mill basis. In many cases, the table drives are mounted on the motor room side of the mill and are close to the motor room wall. In this case, the panels are physically located in the motor room nearest the wall opposite the mill. In the case of the runout tables, the tables are not near the motor room and the protective panels are physically mounted near the tables, out in the mill area. ▲

Beneficiation of Iron Ore By Conductivity Separation

by M. B. MAIRS, Manager

Minerals Dressing Equipment, Mining and Construction Dept., Joy Manufacturing Co., Pittsburgh, Pa.

Dry ore beneficiation of non-magnetic ores using the high-tension process promises low cost operation coupled with simplicity and small space requirements.

THE trend in the iron and steel industry today shows that more emphasis on the industry as a process from raw materials to steel will be given to raw materials. There has been a steady emphasis on increasing productivity by upgrading raw materials. In recent months, trips by engineers to Europe and Russia have dramatized the results of the new techniques in using upgraded ores and size-controlled blast furnace feeds. The newer equipment and techniques used in Europe and Asia show some striking savings. The use of self-fluxing ores, the increased use of oxygen in steelmaking, the increasing use of sponge iron from direct reduction and the increasing use of controlled particle sized charges point to the economics of carefully preparing the raw materials going to the steelmaking furnaces. New efficiencies have come about as a matter of necessity.

U. S. reserves of direct shipping ores have diminished

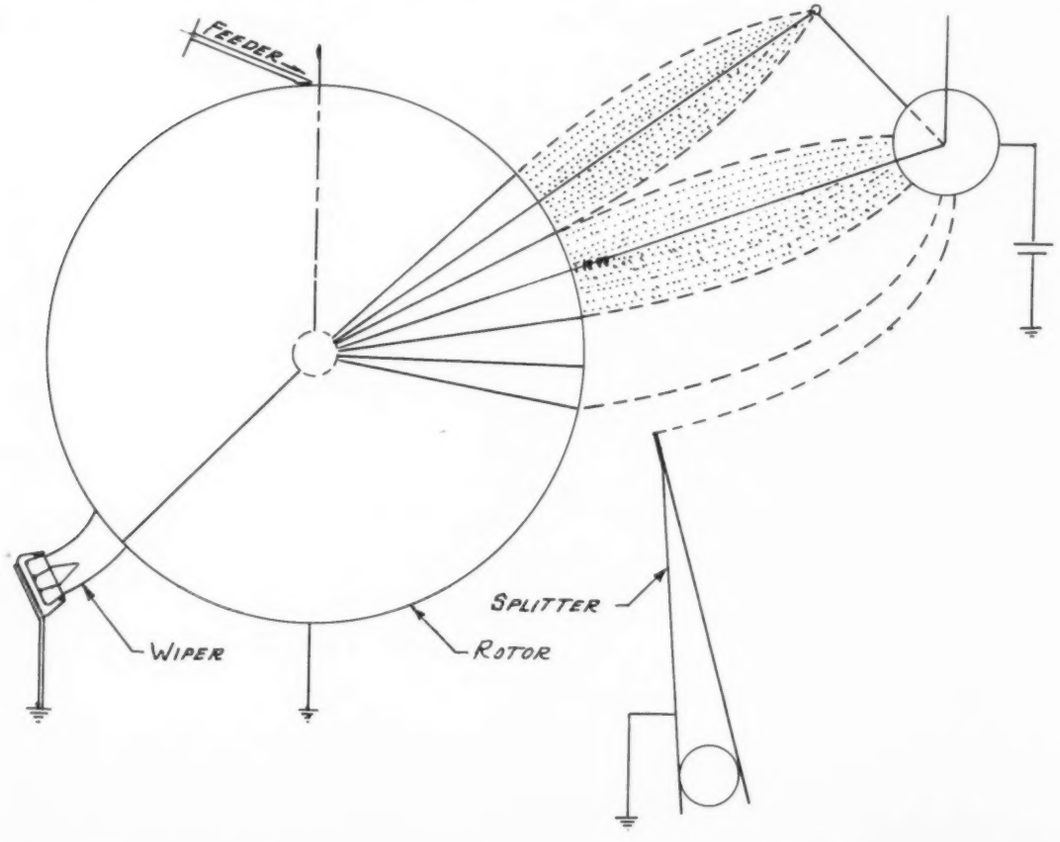


Figure 1 — An important feature of the process is the simplicity of the equipment.

to the point where low-grade taconites are now being mined on a large scale. In the past, direct shipping ores have been recognized as 50 to 55 per cent Fe. Ores are now being mixed containing in the neighborhood of as low as 25 per cent iron and are being beneficiated. These ores, upgraded to 65 per cent Fe or more, are now proving to be more economical to smelt over many of the direct shipping ores. These economics include the increased cost in the flow sheet of beneficiating the ores. It has been shown, for example, that by charging a beneficiated iron ore to the blast furnace, together with a feed of an ideal particle size, thermal efficiencies in the blast furnace are so improved to show as much as an 18 per cent gain in iron rate and a reduction in the coke rate of up to 22 per cent.

By using fully prepared high iron content burden, coupled with the newer techniques of hotter blasts, the use of oxygen and other techniques, the average capacity of our blast furnaces can be increased from 20 to 30 per cent. Data has been compiled to show that in a pig of steel, 75 per cent of its cost comes directly from the raw materials that make it. It has been calculated that beneficiating type equipment costs just about one-third of smelting type equipment. Therefore, it is fairly obvious that the iron and steel industry in the coming years will spend much time and money on raw materials.

In the past methods used to beneficiate iron ores have mostly been either gravity or magnetic concentration or combinations of both. Gravity concentration methods are efficient as long as the iron oxides in the ore liberate at fairly coarse particle sizes. However, as the ore must be ground down to finer sizes, approaching particle sizes of slime material, gravity separation is not practical. Magnetic methods of beneficiation are limited to the magnetite ores and hence, are not applicable to the hematites or nonmagnetics. In some cases, another somewhat costly step is taken wherein some hematites are put through a reduction roast so that they can be recovered by magnetic separation.

The major iron companies for some years now have been looking for better methods of iron ore beneficiation. In many ore bodies, both hematites and magnetites occur together and as in the case of the Jones and Laughlin Benson Mine, two processes are used to beneficiate the ore; magnetic separation at the one end of the ore body for the magnetite, and wet gravity separation at the other end for the hematites. Certainly, one process to handle both ends of the ore body would be attractive. In the tremendous Canadian ore reserves of Quebec, Labrador and Ungava, the need for a dry beneficiation process in Arctic or sub-Arctic climate is obvious.

It was just two years ago that inquiries were first made on the application of the high-tension process for use in iron ore beneficiation. This process had previously been applied to the concentration of tin and titanium minerals. The adoption of this high-tension technique used on the Florida beach sands was adapted to iron with only slight modifications. The term, high-tension, has been used to define the technique employing electrostatic fines at very high voltages. The technique is best illustrated by Figure 1. Ore in pulverized form is fed at precalculated rates to a turning rotor which will vary in diameter and length to suit particular ore recovery requirements. The rotor connected to ground

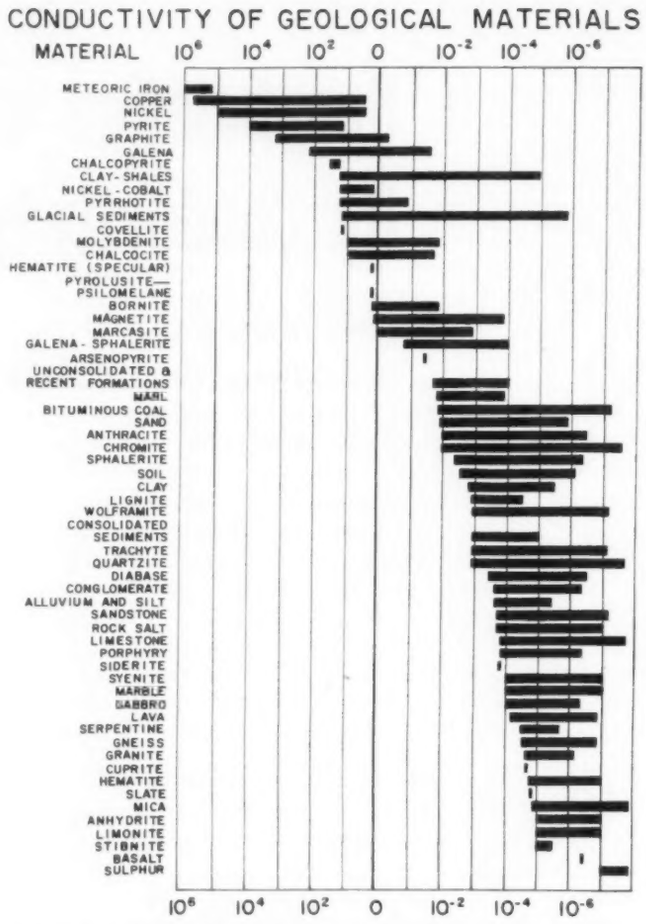


Figure 2 — Chart gives relative conductivity of various geological materials.

potential is dynamically balanced on its axis and is v-belt driven. The speed of rotation is calculated so as to impart kinetic energy to the ore particles for the subsequent process. An electrical potential in the form of approximately 40,000 volts as a rectified direct current is then applied to the electrode section of the apparatus.

The electrode section is itself composed of two parts in the form of a double electrode. One part of the electrode is a static electrode, a 1-in. diam tube, and the other part is composed of an ionic electrode, a thin tungston wire. Depending on the particular ore, there may be arranged two sets of these ionic and static electrodes.

The static field distance from static electrode to the surface of the rotor can be changed to suit the ore being handled. The ionic electrode can be oriented around the static electrode and in relation to the grounded rotor. The field distance between rotor and electrode is set to maintain only occasional sparking across the gap and to maintain audible corona discharges across the gap. There is a relatively heavy flow of ions across this gap in the ionic field and these ions are continually bombarding the mineral particles being fed across the rotor. As the ionic electrode sprays all the mineral particles, each one develops a net identical surface charge. Since the grounded rotor is opposite in potential, all mineral particles are momentarily pinned to the grounded potential rotor. Again depending on the ore, it may react better to negative or positive discharge.

As the mineral particles then leave the ionic field,

the good conductor mineral particles, such as specular hematite or magnetite, leak off the sprayed-on charge quickly. Because they are in contact through to ground potential, they are free to be flung off the rotor. As they then leave the rotor with a slightly net positive charge, the reflector section of the electrode attracts them and lifts them a little farther to spread the separation. The poor conductor minerals, such as silica, as they pass out of the corona field, are unable to leak off their net negative charge quickly and are kept pinned to the positive rotor around to a point where they are swept off. It is this combination effect that is the secret of success in this field permitting an efficient separation of minerals according to their relative electrical conductivity. Figure 2 lists various minerals according to their relative position as to electrical conductivity. Minerals which are poor conductors will be readily separated from minerals shown as good conductors.

In the case of iron ore beneficiation, the ore of course must first be crushed to a point where the iron particles are liberated from the associated siliceous gangue. The ore must be dry since the separation phenomenon is based on the surface conductivity of the mineral particles. The mineral particles must be free of slime coatings. This, in effect, means that the process will be effective on hematites, martites and magnetites and will not be effective on the hydrated minerals such as limonite. Therefore, in this process a drying step must be considered. The amount of drying will depend naturally on the flow sheet prior to separation. If the ore is crushed and ground in a dry process such as in air-swept autogenous mills or air-swept impact mills, it is likely that

Figure 3 — A flow sheet for the high tension process shows the steps required to obtain a concentrate of over 65 per cent iron from an initial martite ore of about 25 per cent.

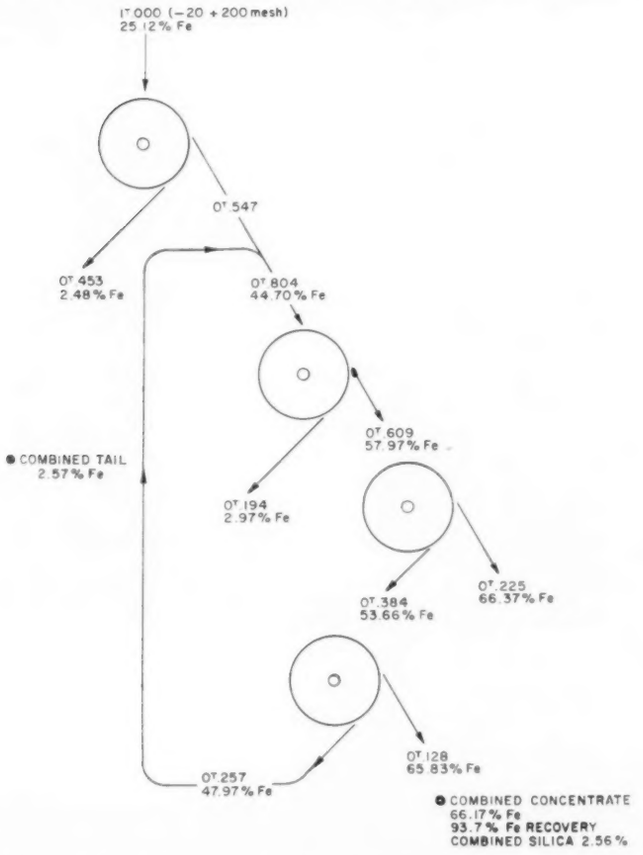


TABLE I
High Tension Process
Estimated Direct Operating Costs Per Long Ton of Iron Ore
Basis: Minimum plant of 5000 tons of feed per day using 5.6 ft of rotor to process one long ton of ore.

Item	Rate	Computation	Cost Per Ton Treated
Maintenance (labor and material)	0.274¢ per rotor ft per hr	5.6 x 0.274¢	1.534¢
Power costs	1.0¢ per kwhr	5.6 x 0.0418 x 1.0¢	0.234¢
Operating labor	$5000 per year per man	2 men per shift, 4 shifts 350 days per year	2.286¢
		Total	4.054¢

the discharged particles from these mills will be suitable directly to the separator.

In practice, a flow sheet will look something like that shown in Figure 3. In this case a martite ore 25.12 per cent iron is fed across a rougher section, wherein a 2.48 per cent iron tail is rejected and the concentrate from this rougher is then fed to a cleaner section. The cleaner rotor rejects a 2.97 per cent iron tail and feeds a 57.97 per cent iron concentrate to a re-cleaner rotor section. The re-cleaner section makes a 66.37 per cent iron concentrate and the re-cleaner is scavenged to make a 65.83 per cent concentrate and recirculating a 47.97 per cent iron tail to the first cleaner section. The combined concentrate then gives 66.17 per cent iron with a 93.7 per cent iron recovery and with a combined tail with a 2.57 per cent iron. In a plant designed to handle, for example, 1000 tons ore per hr, there would in practice be a bank of roughers and a bank of finishers. The feed rate to a separator plant is generally rated in lb of feed loaded per in. of lineal rotor length per hr.

An average expected loading will be 150 to 200 lb per in. rotor length per hr. This means about 2 to 3 ft of rotor will be required to completely beneficiate an average ore at a rate of one ton per hr. This average ore would yield a concentrate close to 65 per cent iron, would yield a rejectable tail and would recover something greater than 90 per cent iron in the concentrate from the original feed. A 1000-ton per hr mill would therefore require about 2000 to 3000 lineal ft of rotor in the form of banks of machines. These machines, assembled in banks, are of course designed as completely integrated machines and each bank is composed of a series of stacked rotors. To give an idea of the space requirements, a machine to handle a complete separation of an average ore at the rate of 10 tons per hr would occupy a space of about 6 ft by 5 ft by 5 ft. This is a fairly compact plant for this type of work. Although there have not, as yet, been any operating costs developed in an iron beneficiation plant, there are available complete data on commercial installations of the same type of equipment based on ten years of experience from machinery beneficiating iron titanium sands. Table I shows an expected total operating cost of about 4¢ per long ton processed.

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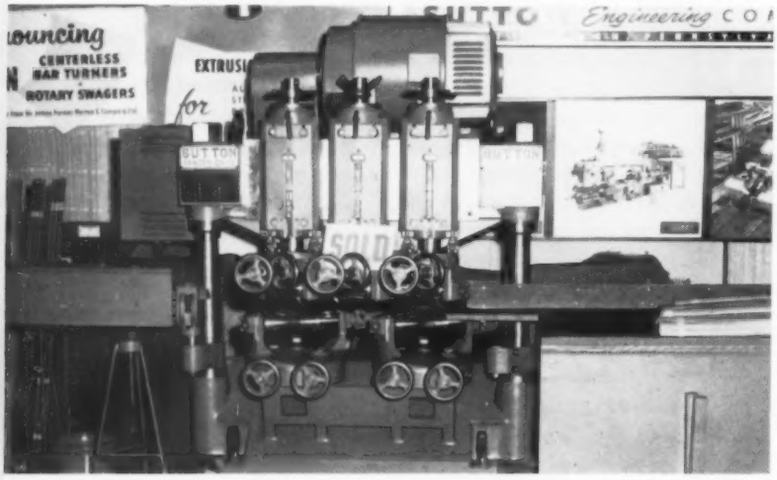
2. "Electrical Concentration of Iron Ore," by W. P. Dyrenforth, AIME, Tampa Meeting, 1957.
3. "Technical Progress in Iron and Steelmaking," by H. S. Turner, 1957 (Unpublished address). ▲

PICTORIAL REVIEW — 1960 AISE CONVENTION

▲ Replica of a "Prodac" installation on a recoil line was a feature of the Westinghouse exhibit.

▼ One booth purchase was this straightening machine displayed by Sutton Engineering Co.



▲ The Heyl & Patterson booth, with an operating model of an ore bridge, holds the attention of these registrants.

▲ D. F. Fessler (left), Zurn Industries, Inc., discusses features of his company's pipeline strainer with Howard Price, McDonald Works, U. S. Steel Corp.

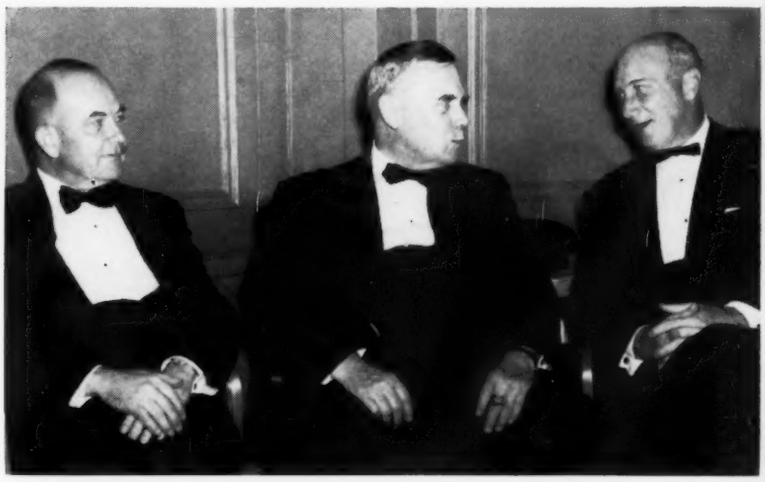
◀ Nelson Stud Welding's exhibit draws an interested audience.

AND EXPOSITION

Cleveland, Ohio
September 27, 28, 29, 30

▲ Authors and chairmen attended pre-session meetings each day. Above are Electrical Session members. Seated are D. E. Abell, J. A. Drgon, and Thomas Harmon. Standing are R. W. Sonnenfeldt and R. W. Kirkland.

▲ Operating Practice Session members are (seated) R. W. Holman, H. E. Rowen, C. D. Thompson, and W. E. Schwabe; (standing) J. A. Bauscher and W. A. Black.



C. H. Williams, Administrative Vice President, Engineering, U. S. Steel Corp., C. W. Holmquist, Executive Vice President in charge, Aristoloy Division, Copperweld Steel Co., and V. H. Leichliter, President, American Steel and Wire Division, U. S. Steel Corp., were among the guests attending the annual banquet. ▶

View shows speakers' table and part of the 1100 persons who attended the banquet. ▶

Louis Moses Wins AISE Papers Award

AT the AISE annual banquet, September 29, the 1959 Kelly Award winners were announced. Louis Moses, now retired, formerly mill engineer of Bethlehem Steel Co., Bethlehem, Pa., was awarded first place for his paper, "Mathematical Aids to Determine Spread and Reduction Rates in Rolling."

The paper was published in the December, 1959, *Iron and Steel Engineer* and outlines a simplified procedure for handling the Ekelund spread formula which will be invaluable to the roll designer. Mr. Moses also received a first place Kelly Award in 1951 for his paper, "A Report of Rolling Experiences."

Winners of second place were Henry C. Bigge, former superintendent, tool steel and electric furnace melting dept., and Elliott A. Reid, assistant chief metallurgist, Bethlehem Steel Co., Bethlehem, Pa., for their paper, "Vacuum Pouring for Large Forging Production." This paper cites a major advance in quality steelmaking techniques, showing how vacuum pouring reduces the hydrogen content of electric furnace steel by 60 per cent, resulting in a flake-proof composition, elimination of hydrogen embrittlement, improved tensile ductility and a cleaner steel. This paper appeared in the April, 1959, *Iron and Steel Engineer.*

For their paper, "Recent Developments in Design and Control of Hot Strip Mills," R. W. Barnitz, chief electrical engineer, and H. H. Shakely, plants engineer, Jones & Laughlin Steel Corp., Pittsburgh, Pa., won third place. This paper describes how automatic programming control provides single-stand reversing roughers with sufficient capacities to keep steel in the hot strip finishing stands at all times at the Aliquippa and Cleveland works of the Jones & Laughlin Steel Corp. The paper also was printed in the April, 1959, *Iron and Steel Engineer.*

Three papers closely followed the award winning papers in the selection and were given honorable mention. These are: "New Operational Features on Patricia Blast Furnace at Fairless Works," by R. H. White, superintendent blast furnaces, W. O. Smith, electrical engineer, and P. E. Hutchings, fuel engineer, all at Fairless Works, United States Steel Corp., which was published in the June, 1959, *Iron and Steel Engineer;* "Quality Control at Pittsburg Works," by G. A. Jedenoff, now general superintendent, Geneva works, Columbia-Geneva Steel Div., United States Steel Corp., in the December, 1959, *Iron and Steel Engineer;* and "Modern Design of Slab Reheating Furnaces," by H. C. Henschen, special engineer, fuel department, Bethlehem Steel Co., Sparrows Point, Md., which ran in the October, 1959, *Iron and Steel Engineer.*

The Kelly award carries prizes of $300, $200 and $100 for the first, second and third place respectively. The award was established in 1943 to honor John F. Kelly, managing director of the AISE from 1917 to 1934, and to perpetuate the memory of his achievements in the advancement of the Association.

The award is made each year by the board of directors of AISE upon the recommendation of the editorial and executive committees of the Association.

Rules of the award:

1. The award shall be given annually to the author of the best paper adjudged of greatest value in the advancement of engineering or operating practice in the iron and steel industry.

2. The entries for each judging shall be the papers published in the *Iron and Steel Engineer* during each calendar year, although some may have been presented at meetings in the previous year.

Voluntary contributions of papers not presented at meetings but published by the AISE are also included in the judging.

3. To be eligible for the award, the author must be directly employed in the iron and steel producing industry. The author need not be a member of the Association of Iron and Steel Engineers.

4. The award shall be made at the annual fall meeting following the close of the calendar year.

5. The award shall be made by the board of directors of the AISE on the recommendation of the executive committee of AISE. ▲

AISE president, S. C. Read (center), congratulates R. W. Barnitz and Louis Moses for their prize-winning papers. Mr. Moses won first place, and Mr. Barnitz, was co-author of the paper that took third-place honors.

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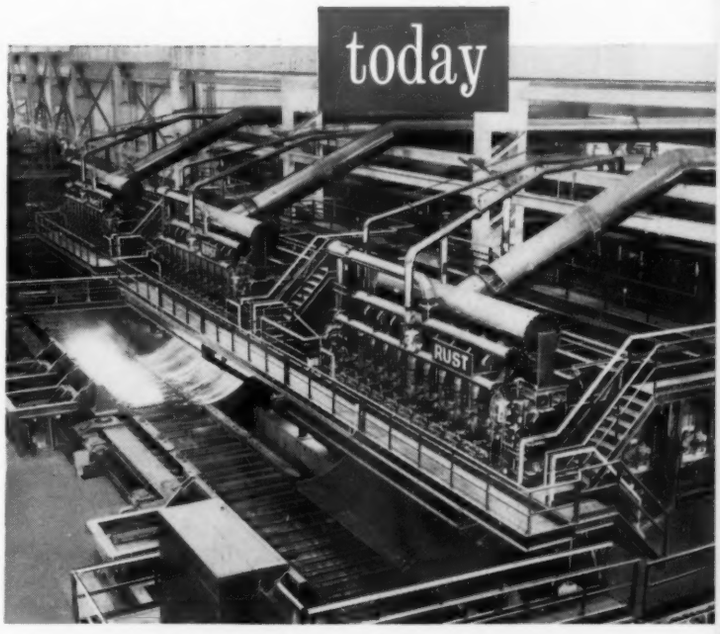

Modern three-zone, continuous furnace now reheating slabs for Kaiser Steel Corp. 86" Hot Strip Mill, Fontana, Calif.

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Overhead electric traveling cranes, gantry cranes, open hearth special cranes, plate mills, blooming mills, structural mills, shears, saws and auxiliary equipment.

J & L Adds to Computer Capacity

JONES & Laughlin Steel Corp., the first in the steel industry to install an analog computer to facilitate extensive research in various steelmaking processes, plans to add even more of this complex analog equipment. The addition of this equipment will more than triple the original capacity installed in September, 1957.

The new equipment, which includes operational amplifiers with computing networks, arbitrary function generators and other auxiliary equipment, will be put into operation later this year at the Graham Laboratory for J&L Research, Baldwin Hill, Pittsburgh.

The new equipment will permit more rigorous simulations of steelmaking processes. Utilizing the enlarged analog computer, J&L will learn more about methods for obtaining high blast temperature, improve control of metal temperature and composition at the basic oxygen furnace and open hearth, and move toward attaining the highest quality of our annealed products.

The analog computer is a highly accurate tool that enables engineering and research personnel to simulate complex metallurgical and mechanical processes electronically, and thus save many hours of involved calculation.

The traditional procedure for determining what happens in a metallurgical process, where certain factors such as time and temperature may be changed for more efficient results, was to build a pilot model, or a full-scale plant, and methodically make all of the changes and combinations of changes one at a time.

Now, in order to obtain accurate information on the way a blast furnace stove operates, a stove is equipped with the thermocouples imbedded in the checker bricks inside the stove itself. Mathematical equations are derived which describe the processes of heat transfer in the stove.

These equations, which normally would take months to solve, are programmed on an analog computer. The equations then can be solved in a matter of minutes; three hours of stove operation can be simulated by the computer in less than 30 sec. Verification of the computer results is obtained by comparing them with the thermocouple data.

The analog model of the blast furnace stove set up on the computer has been used to forecast immediately the performance of the stove that would result from many modifications in design and operation. This approach has enabled research and engineering personnel to specify design and operational changes in the stoves which will result in considerable savings in future capital investment.

While this result also can be accomplished through mathematics, the computations are so complex that a mathematician might work years in reaching a solution.

Actually the analog computer uses a combination of pilot plant and mathematical techniques. It serves as a scale model bridging the gap between the mathematical symbols

Figure 1 — Jones & Laughlin Steel Corp. plans to add even more of this complex analog equipment.

and physical processes. In this simulation of a process, the computer is considered a miniature plant and is operated exactly as its counterpart, without the limitations of time and expense.

With the computer, an investigator can change in a few hours the variable factors through thousands of possible combinations. By doing this, he can get an answer, in graph form, of any combination of factors involved. Extreme conditions in an operation which might cause serious upsets in production, yield, or quality can be tried on the computer without any of these difficulties.

Data from the process itself are used in establishing the model on the computer. When the computer model behaves the same as the actual process, accurate studies of different conditions as they affect the process then may be performed on the computer.

In computer operation, mathematical equations describing the problem are programmed on a removable patch board, similar in design to a telephone switchboard. Patch cords, resembling telephone cords, are "plugged" into the board for proper interconnection of the computing elements. This arrangement permits any necessary changes during the solution of the problem.

Once the equations have been set up on the board, it is securely locked into position on the computer. The tips of the patch cords are engaged by corresponding contact springs positioned directly behind the board to establish the necessary electrical connections for all computing elements.

Potentiometer dials, which control various data involved in the solution of the problem, are set to their proper numerical values. This is the final step in programming of a problem.

The analog computer solves the entire problem simultaneously in the exact manner indicated by the mathematical equations. There is no delay while large amounts of numerical data are converted into understandable form. Related curves are drawn as fast as computation of the problem takes place. When the problem has been solved, an accurate pen and ink graph appears on the plotting board ready for study and evaluation.

J&L's new computer equipment is being purchased from Electronic Associates Inc., which manufactured the original unit. ▲

SOLLAC Operates Kaldo Steelmaking Plant

A REPORT on the first four months of steelmaking by the Kaldo process at Societe Lorraine de Laminage Continu (SOLLAC) in France show heats averaging 125 net tons with an average oxygen consumption of approximately 2100 cu ft per net ton of steel. Dust caught in the recovery system equals 10 lb per net ton of steel produced and contains 65 per cent Fe. Dust in the discharge from the recovery system is said to average less than 5 grains per cu ft. Charges run 61 per cent iron and 39 per cent scrap. Lime consumption is 200 lb, ferroalloys 10 lb per net ton.

Thus far, the unit has produced about 44,000 net tons on a single-turn basis, as it has been necessary to break in all new crews. Hence, production rates have not really been established.

For a typical heat of steel for deep-drawing sheet material, the initial charge might consist of 85 net tons of hot iron running 0.35 per cent manganese, 1.75 per cent phosphorus, 0.04 per cent sulphur and 0.5 per cent silicon. About 13,000 lb of lime are added, as well as 55 net tons of scrap in several additions with intermediate blowing.

At slag-off, the bath might contain 0.35 per cent carbon, 0.2 per cent manganese, 0.035 per cent phosphorus and 0.02 per cent sulphur. Bath temperature might be 2875 F.

After slag-off, more lime is added, followed by ore if the bath temperature is too high. Blowing is continued until the desired carbon is reached

After deoxidizing additions are made in the ladle, steel might run 0.05/0.07 per cent carbon, 0.28/0.40 per cent manganese, with phosphorous and sulphur each below 0.015 per cent. Nitrogen will be less than 0.002 per cent.

The final slag is kept in the vessel for the next heat. The flush slag, similar to that from the Thomas process, is high in phosphorus and can be used for fertilizer.

The sheets rolled from Kaldo steel are said to have mechanical characteristics superior to those of open hearth steel made in the plant.

The SOLLAC installation has one operating stand with two interchangeable vessels. The vessels are moved back and forth between the operating stand and the relining stand by a self-propelled car running on special tracks and turn-table.

The installation is served by a 175-ton ladle crane and 13-ton scrap buggies. Fluxes, ore and other additions are fed from overhead bins and hoppers. Steel is tapped into a ladle resting on a car which carries it into the pouring aisle.

Oxygen comes from a plant rated at 255 net tons of oxygen per day. ▲

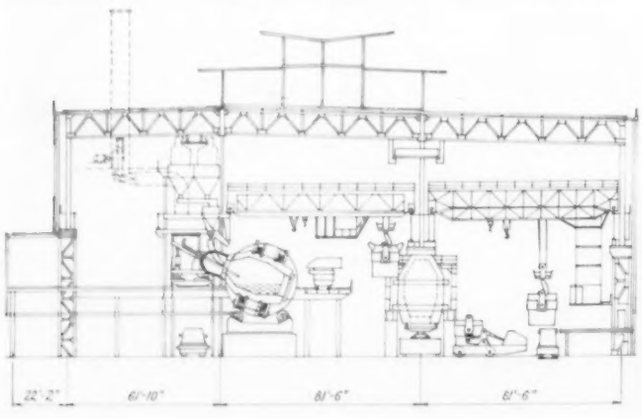

Figure 1—Side elevation of SOLLAC's Stora-Kaldo facility in the Lorraine area of France. One of the two 110-ton vessels is shown (left center) in the rotating cradle; the other is in position on the relining stand.

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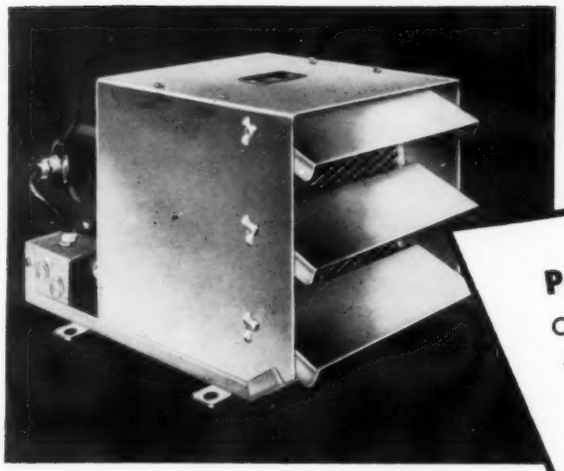
P-G CONVECTION HEATERS



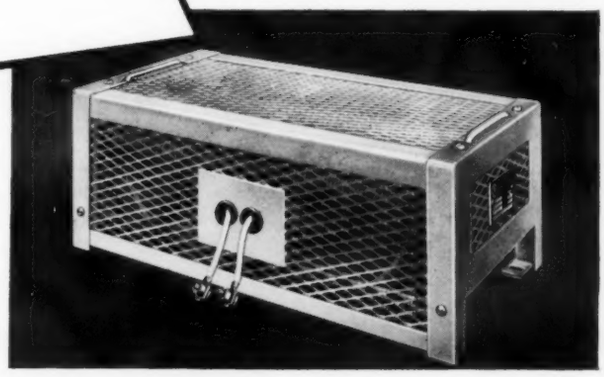
P-G Forced Convection Heater

Capable of moving a large volume of air with little noise. A 250 Volt D. C. Compound Wound Ball Bearing Motor of ¼ H. P. drives the fan. The heating circuit is controlled by a separately mounted 50-Ampere Magnetic Contactor energized thru a snap switch. The fan circuit is controlled thru a snap switch and contains a rheostat to vary the fan speed. Heating elements from 4 to 9 KW capacity, 230-250 Volts, D. C., are available.

P-G Natural Convection Heater

Ruggedly constructed, yet light in weight, they are easily portable by repair or construction workers. Ideal for permanent wall or floor mounting in crane cabs, etc. If a portable unit is desired, its disappearing handles may be used for ease in carrying. Made regularly in 3 to 6 KW capacity, 250 Volts, D. C.

TWO TYPES of HEATERS are available for industrial service. The heating element of both units is made of P-G Type T2, Chromium Steel Grids, which, because of their thin cross section, develop an unusually large heating area. A greater volume of warm air is so produced, and in addition, a more uniform heat distribution is obtained.



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The Nonbreakable Steel Grid Resistor

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The design, engineering and supply of oxygen steelmaking plant up to complete melting shops is the main concern of Davy United's Steel Processes Division. In support of these services, the Division offers metallurgical, technical and economic surveys to help any company planning a new steelmaking development.

DAVY-UNITED STEEL PROCESSES DIVISION

SHEFFIELD, ENGLAND

Granite City Uses Off-Site Technique In Rebuilding Blast Furnace

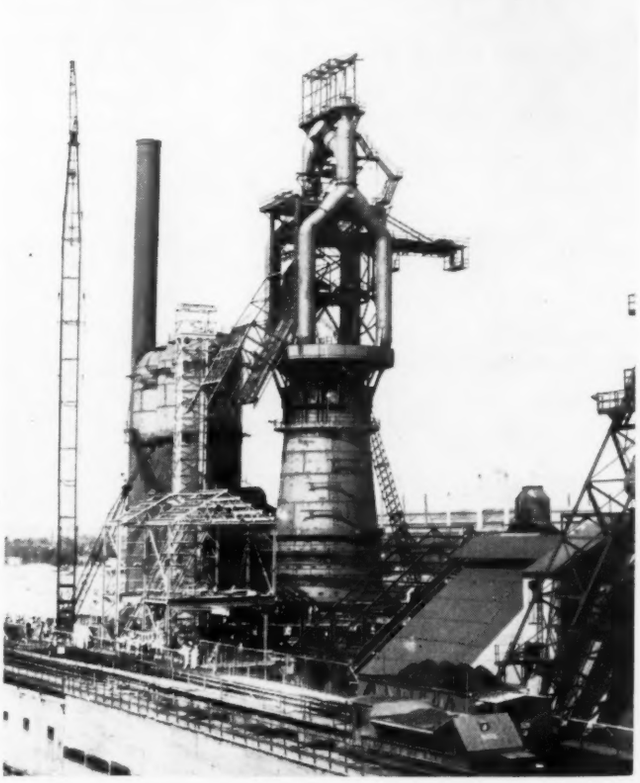
TABLE I
New Granite City Steel Co. Blast Furnace

Nominal capacity in tons	1,800
Diameter of hearth, ft	28
Diameter of bosh, ft-in.	31-3
Diameter of stockline, ft	22
Height, iron notch to stockline, ft-in.	89-10½
Height of crucible, ft-in.	11-7½
Height of bosh, ft	11
Height of straight section, ft-in.	11-6
Height of inwall section, ft-in.	52-9
Height, stockline section to top ring, ft-in.	22-8
Height, bottom to iron notch, ft	2
Height, cinder notch to tuyeres, ft-in.	3-4
Height, ground level to top of bleeder platform, ft-in.	215-6
Working volume, tuyeres to stockline, cu ft	46,930
Bosh angle, deg-min-sec	81-35-40
Inwall slope, in. per ft	1,052
No. of tuyeres	20
Tuyere diameter	6 × 15 in.
No. of columns	8
Lining thickness, crucible, carbon, ft-in.	2-3
Lining thickness, bosh, carbon, ft-in.	1-3
Lining thickness, stack ft.	3
Lining thickness, throat, ft-in.	2-8⅜
Big bell diameter, ft	15
Big bell angle, deg	53
No. of brick in furnace	243,070 actual brick 610,000 9-in. equivalent
Number of stoves	3
Diameter of stoves, ft	22
Height of stoves, ft	132
Checker openings	245.8
Heating surface of stoves, sq ft	220,245
Small bell diameter, ft	7

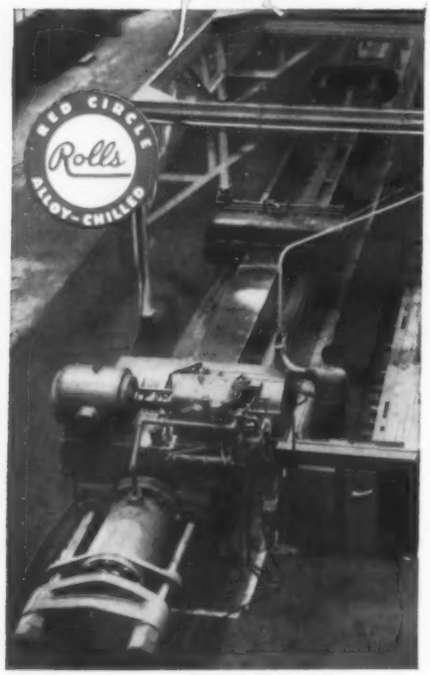
A 700-ton, prefabricated section of a new blast furnace at Granite City Steel Co. was moved into position in the furnace structure today by a crew of heavy moving specialists. This unusual operation has been performed only four times previously in steel industry history, according to the Koppers

Figure 1—Blast furnace shell and superstructure as moving day began at Granite City Steel Co. on Monday, August 22, 1960. At this time, the shell and superstructure—total weight about 700 tons—were 87½ ft from their final resting place.

Figure 2—At 9:40 A.M. on August 22, 1960, one hour and forty minutes after the move began, the blast furnace shell and superstructure had been pulled into position above the ends of massive H-beams rising from the foundation of the new Granite City Steel Co. blast furnace.



Hyde Park
STRETCHER LEVELLERS



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Adaptable for automatic cycling.

Pneumatically or hydraulically operated wedge or toggle type jaws.

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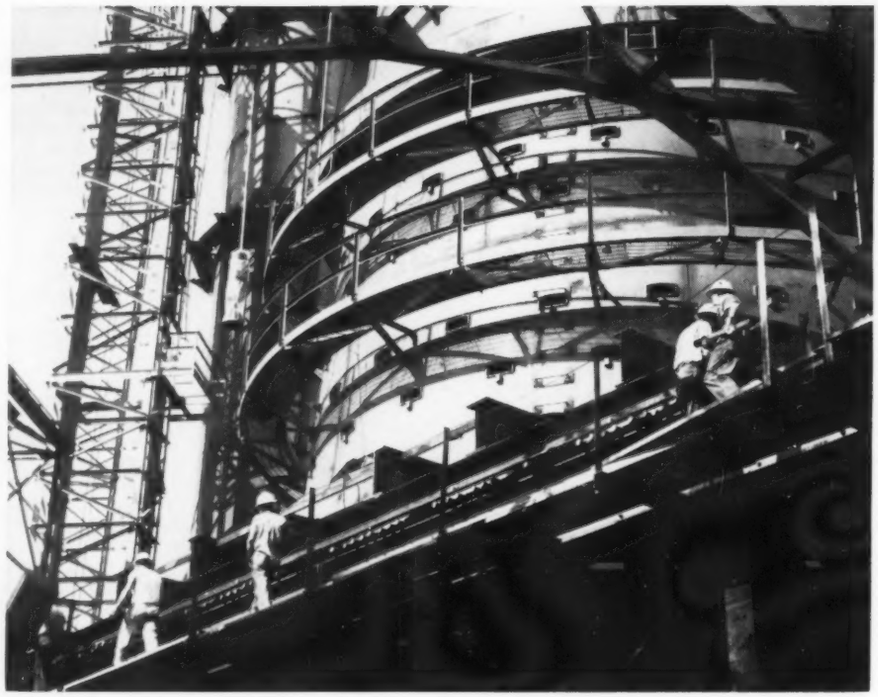

Figure 3—The 700-ton blast furnace shell and superstructure were pulled over a trestle on steel rollers.

Co., Inc., which is building the new blast furnace.

The steel shell and much of the loading and gas removal apparatus of Granite City Steel's new blast furnace were assembled several months ago on top of a 45-ft-high steel platform. The platform was 87½ ft from an old blast furnace that was continuing to produce pig iron at that time.

Because of their great size, blast furnaces are usually built from the foundation up. In this case, the purpose in prefabricating part of the furnace "off-site" was to shorten the length of time required to tear down the old furnace and build the new one on the same foundation.

The platform and the position the shell was to occupy in the new furnace were connected by a trestle after the old furnace was "blown out" and torn down. A 30-man crew from the Eichleay Corp. of Pittsburgh pulled the prefabricated section, a structure 177 ft high across the trestle on steel rollers.

Motive power was supplied by the drum of a heavy truck crane. A pull of 96,000 lb from a ¾-in. steel cable from the drum through a block and tackle arrangement before connecting the cable to the base of the prefabricated section was needed for the move.

It took 1 hr-40 min to move the blast furnace shell the 87½ ft. After that, the Eichleay workmen began the longer job—11 to 12 hr will be required—of lowering the shell and furnace superstructure 3 ft 4½ in. onto a circle formed by the ends of massive H-beams that rise from the foundation of the new blast furnace. Twenty-four big jacks are being used to bring the shell into perfect alinement with the rest of the furnace.

The blast furnace process consists of charging iron ore, fuel (coke), and flux (limestone) into the top of the furnace and blowing heated air (blast) into the bottom. When it is completed late in October, Granite City Steel's new blast furnace will be about as tall as an 18-story office building. In operation, it will consume more than 5500 tons of raw material a day, producing about 1800 tons of pig iron for use in the company's steelmaking open hearth furnaces. The blast furnace and its contents will put a load of about 20,000,000 lb on its foundation.

The new furnace is one of the key units in an expansion program at Granite City Steel's 550-acre plant in Granite City, Ill., nine miles north of downtown St. Louis.

Granite City Steel is the largest steel producer in the St. Louis area and operates the area's only blast furnace plant. ▲

A two-pass blast furnace stove with application of TAMUL brick and shapes shown in red.

Increasing hot blast temperatures?

REINFORCE CRITICAL STOVE AREAS WITH TAMUL BRICK AND SHAPES!

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Excellent resistance to thermal spalling, alkali attack, and subsidence under long-term hot load, along with high refractoriness (P. C. E. — Cone 39) combine to make TAMUL the ideal refractory for these trouble spots. TAMUL should be laid up in new, improved TASIL cement.

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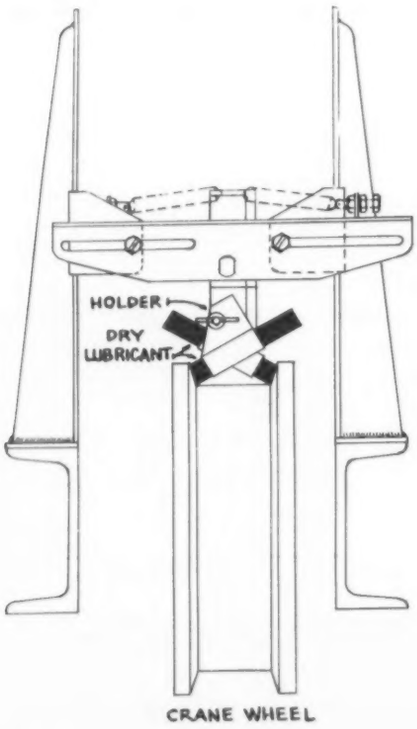
Graphite Lubricant Reduces Flange Wear On Crane Wheels

RINGSDORFF Carbon Corp., McKeesport, Pa., has announced the development of a new process of dry lubrication for flange wheels of traveling cranes that extensively improves operating condition of the cranes and greatly reduces the wear to rails and wheels.

Under operating conditions, the flange wheels and guide rails of undercarriages of traveling cranes may be subjected to extremely costly wear. In the past, oil and grease were used as lubricants. These products proved unsatisfactory because they increased the wear rate of the cranes wheels due to the introduction of dust and dirt deposits gathered in the lubricant. Only after the introduction of Ringsdorff Carbon's entirely new dry lubrication method was it possible to considerably reduce wear and to improve the running behavior of the undercarriages; therefore cutting down maintenance and operating costs.

Figure 1 — One unit on a crane on each end is all that is usually necessary.



After many years of research on the European continent in connection with the finding of a more suitable lubricating agent than pure graphite and also developing an adequate holding device Ringsdorff's graphite carbon grade "D4" was developed. This has many advantages, outstanding of which is the fact that this graphite-carbon grade will fill in pores and unevennesses of the wheel flange and the sides of the rail head within a short period and form a smooth film, scarcely visible to the naked eye, over the wheel flange surfaces. This film is very resistant to pressure and leads thus to an extensive reduction in wear and tear. In addition, the graphite-carbon film is so smooth and hard that no dust or dirt particles will be collected by the wheel flange and rail head sides. The solid graphite film also has the advantage over previous materials in that it will not spread over the contact surfaces of the wheel and the rail head, causing loss of traction. These sticks are rectangularly shaped in a ratio of 2 to 1 and are of a sufficiently high mechanical strength. A rectangular section was chosen—contrary to the round rods now being used in the railroad industry, in order to assure a uniform lubrication film over the circular surface of the wheel flange. These lubrication rods fit in a specially designed holding device which is universally adjustable to fit most traveling crane undercarriages without much adjustment or revision.

Recent case histories have shown that by utilization of this new dry lubricating method, it is not necessary to equip all wheels of each crane being used, since the film is transferred from flange to wheel to flange, etc. In fact, in multiple crane installations, it is only necessary to equip one wheel on each side of the center crane. Even in instances where abnormal wear is now not being experienced the installation of such a dry lubricating system will prolong the life of wheels and flanges and decrease maintenance costs.

In January of this year Ringsdorff completed an installation of its dry lubricating method on a crane used in the electric weld pipe section of one of the largest mills in the Pittsburgh area. Normally these crane wheels used to have a life expectancy of four months service. The dry lubrication method was introduced on wheels, then two months in service. Now, almost a year later these same wheels are still in service and show no additional signs of wear. Maintenance costs have been reduced to a minimum and crane operations are smoother, quieter and easier to start. This mill has since been equipping additional cranes throughout the plant with the Ringsdorff lubricator. ▲

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Jack Russell, National's foundry superintendent, discusses an electric furnace heat with Bill Mason of the sales department.

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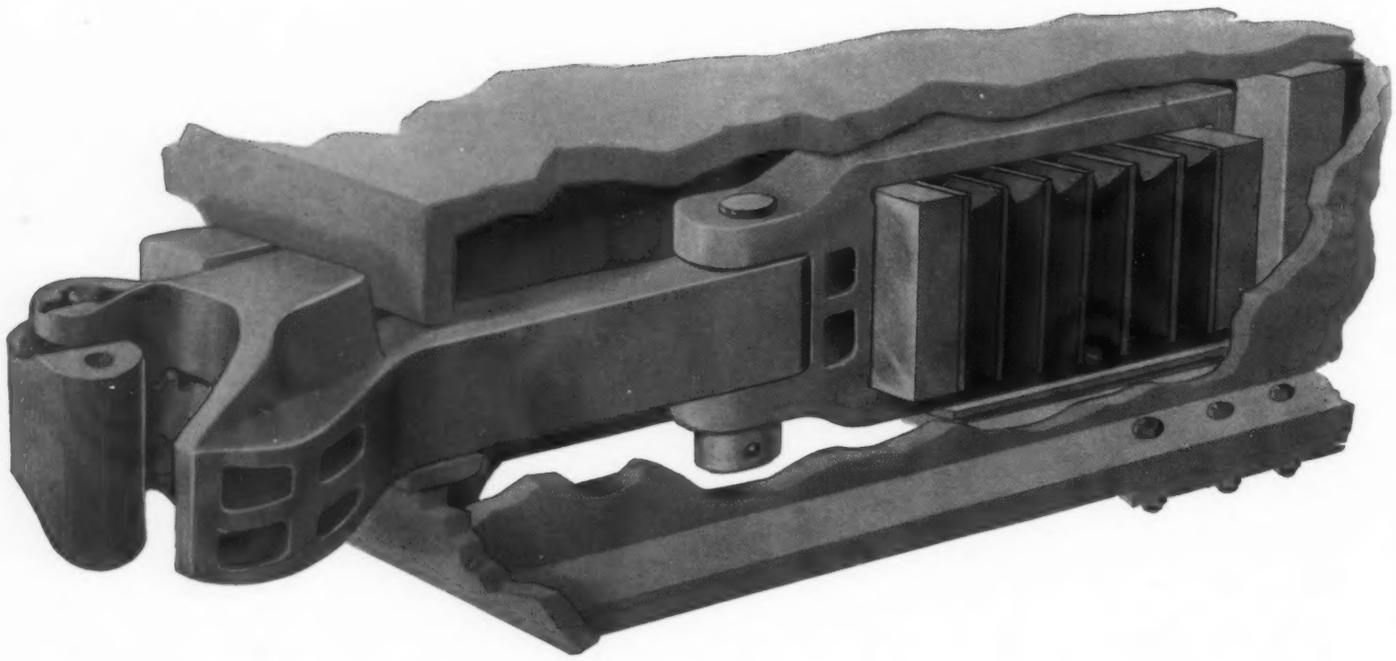

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Steel Plants Add Quality Control to Tinplate Production Lines

USERS of tinplate have been switching over from buying the tinplate in sheared strip form to buying it in coil form. As a result of this change in the production of tinplate, producers soon found that manufacturing their product in coil form presented many severe problems.

When tinplate was shipped in sheared strip form, the individual sheets were inspected and sorted into various classifications. These classifications provided the steel mills with the quality control information necessary to establish the exact amount of prime and secondary grades of tinplate (each classification carries a different base price in the tinplate field). With the manufacture of the tinplate in coil form none of this information was readily available; even the deviations in the predetermined quality of the completed coil became an unknown factor because of the lack of definitive information.

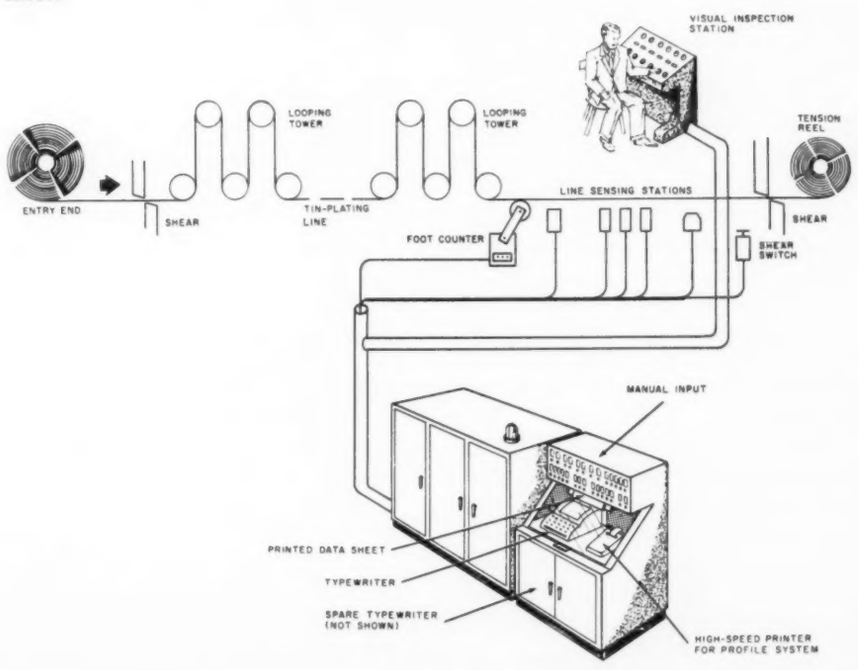
Airborne Instruments Laboratory (AIL), a division of Cutler-Hammer, Deer Park, N. Y., has solved the problems of accumulating all of the necessary quality control data as the coils of tinplate are being run at the rate of 1600 fpm with the development of the AIL data accumulation system. Several of these systems have been installed on the processing lines of some of the nation's leading tinplate producers. The system accumulates all pertinent data from the electrolytic tinning line as the coils are being run and presents the information in the form of a typewritten record.

This system gathers information from a number of sensing devices and visual inspection stations, mounted along the output section of the continuous-process line ahead of the shear and coilers.

The input devices used on the line at one of the steel mill installations include a pinhole detector of the photoelectric type, a beta-ray to measure base metal thickness and provide over-gage and under-gage signals, a set of four x-ray gages to determine tinplate thickness and supply signals indicating top plating light or heavy and bottom plating light or heavy. In addition, a footage tachometer provides an accurate measure of strip length; the two visual inspector's stations provide signals as to footage of visual defects such as color markings, unmelted coating, etc. Welds are located by an operator, who presses a pushbutton as the weld passes his station.

The system consists of a main computer unit that accepts as inputs the signals from the sensing units, accumulates this data, equalizes the information to one point on the strip, calculates and combines information into the required form, and stores it until the coil is completed. When the coil length required has been run, the output shear is operated; this action initiates the printout of the in-

Figure 1 — Schematic of data accumulation system for coil electrotinning lines.



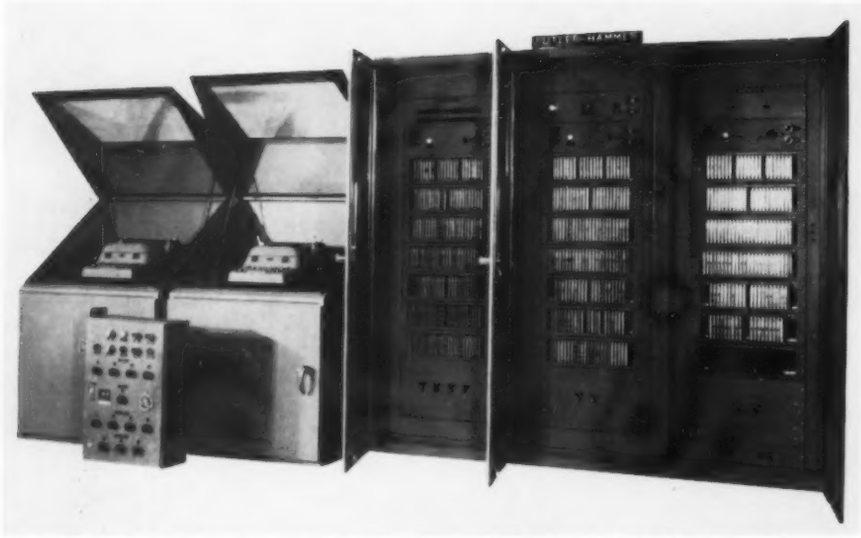


Figure 2 — The data accumulation system shows front left the manual entry panel. The two print-out cabinets are directly behind the manual entry panel, one is generally positioned on the end of the processing line and the second one is located in one of the management areas. The three cabinets (with doors open) are the data accumulators and are located on the operating floor or the control room.

formation pertaining to the completed coil by two electrically operated typewriters—one on the line for the operator's use, and the other in the office of the superintendent of the tin department. The printed information is in decimal form for direct usage.

On the operator's control panel, a number of large dial switches are used to enter data such as date, turn number, lot number, and coil number. This information is printed out at the start of each coil printout for identification purposes.

The main computer contains three identical computers operating in parallel. Each of the three computers contains an input section, a main arithmetic section, a memory section, and an output buffer section. The computer sections utilize Plug-in transistorized logic modules (flip-flops, nor units, driver units, and pulser units). The memory units are magnetrostrictive delay lines. Thus, the entire unit is composed of solid-state devices with no moving parts and very low power dissipation. No cooling devices, blowers, or air conditioners are required.

Each of the three computers contains eighteen information channels which accumulate the data into eighteen registers in the buffer storage unit. Each register has a 20-bit capacity. Binary-coded-decimal notation is used throughout the computer sections.

The eighteen channels in each computer do not exist as separate physical entities but rather appear in time only; the time being defined by when the information enters the recirculating delay lines. This time-multiplexing permits the full use of the inherent high-speed operation of the delay lines without requiring the entire computer section to be operated at high speed. One small section of each computer handles the bits entering and leaving the delay lines; these are all high-speed units. The outputs of the delay lines are handled by more economical low-speed units.

The high-speed section of each computer contains one arithmetic unit. The computers are so organized that this one unit operates sequentially on each of the eighteen channels of information. It is here that information is combined and computed to provide the required results (pinhole-feet, over-gage footage, etc.).

Because the sensing devices that gather the information on the quality of the tinplate are spread over a considerable length of the line, it is necessary to equalize this information so that the printout occurs as if all the data were gathered at the output shear location. This ensures that all the data is printed for the coil to which it belongs. The equalization is accomplished by synchronous operation of the delay lines. Incoming information from the line sensors is stored briefly in the computer input sections and then entered into the recirculating delay lines. The orbit time of the information in the delay lines is then set to be somewhat faster than the speed of operation of the tinning line. The delay time in the input section, together with the orbit time for each piece of information, is selected so as to provide the required equalization for each channel.

Each of the three computers terminates in an output accumulator section in which the coil data are accumulated. When the output shear is operated, the print cycle is initiated, and the accumulator contents are transferred into three output buffer sections.

Following the output buffers is a single voting machine. Upon initiation of a print cycle, this section examines the information in each of the three buffers and checks it for agreement. When all three buffers contain the same answer, that is the correct answer, it is printed. If one of the answers does not agree with the other two, then the majority is made to rule by the voting section, and the two in agreement are printed out. In addition, the fact that one answer was incorrect is kept track of and, after a preset number of such errors, an indicating light is lit to show that the computer is in error and should be checked. The voting is carried out bit by bit.

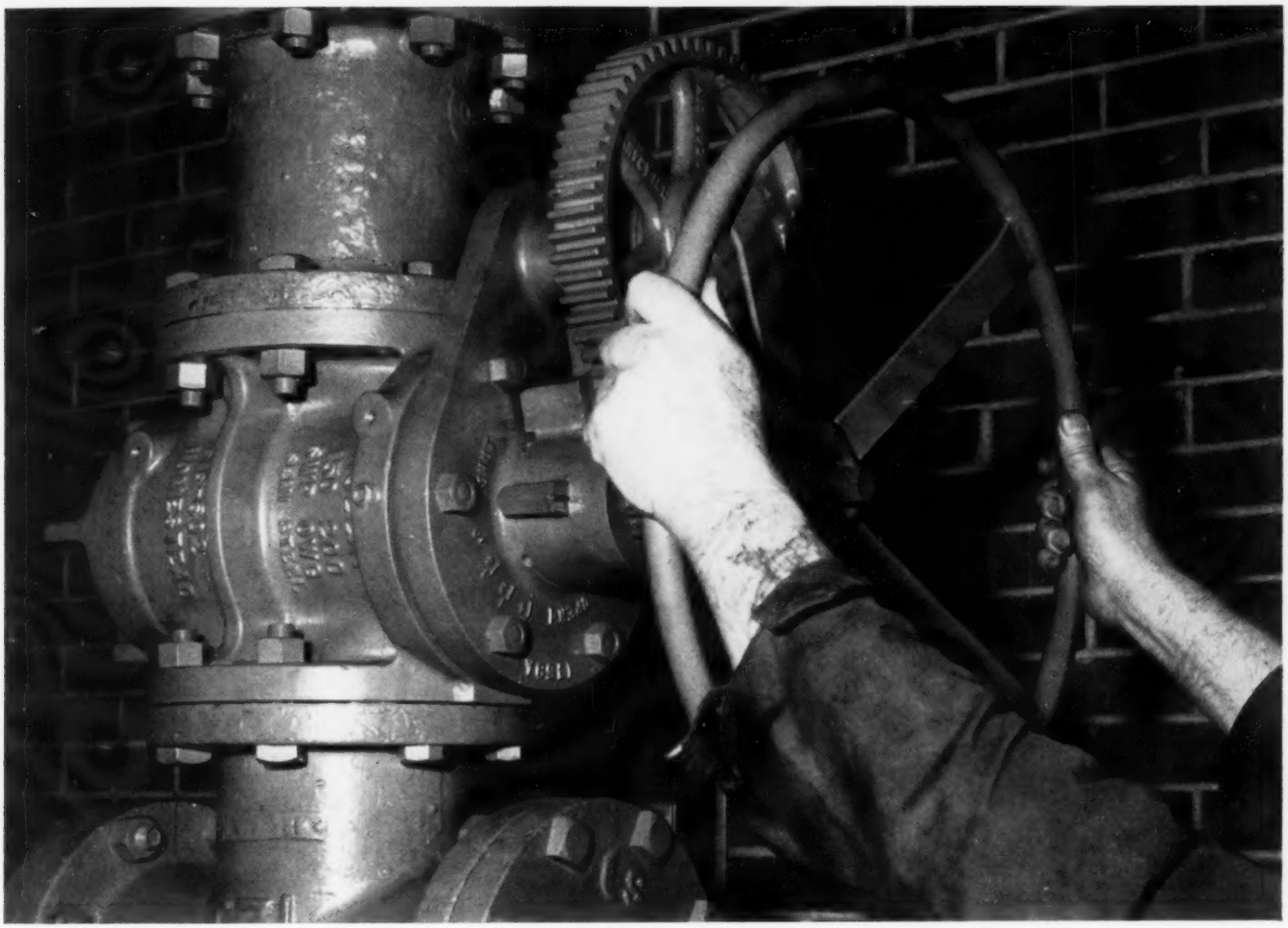
As the correct information is passed from the voting section, it proceeds to the print program section, where the data is organized into the required format and such zeros as are not desired to print are suppressed.

Finally, the information is passed through a binary-coded-decimal to decimal converter into the output amplifiers. These output amplifiers then operate the solenoids on the typewriters.

The typewritten sheet contains in a single row, the date, turn number, lot number and coil number; total feet per coil, total prime feet, pinhole-feet and footage of each of the other defects. In this form, the record is then directly and immediately useful for quality control evaluation, pricing of the coil, setting of incentive pay and production control operations.

100% FLUID CONTROL AT YOUR FINGERTIPS

with Homestead Lubricated Plug Valves. When open, they provide full pipe-sized passage to fluids. Closed, their controlled high pressure lubricant



system, plus extremely close plug and body tolerance, guarantee a complete chemical seal—positive shut-off without contamination of line fluids. Instant response is sure, too, because piston-like movement of plug during each lubrication prevents sticking. They are low in first cost—low in upkeep. Write for complete details.

hv

HOMESTEAD VALVE MANUFACTURING COMPANY
P.O. Box 160, Coraopolis, Pennsylvania

Gentlemen: Please send me Catalog 39-1 and prices on Homestead Lubricated Plug Valves [160]

Name..... Title.....

Company.....

Address.....

City..... Zone..... State.....

The use of the three parallel computers provides many advantages to tinplate manufacturers. First, with three identical computers, the system will provide the required records with all three computers, with any two out of the three, or with any one computer operating normally. Thus, if one or even two of the computers should be shut down for any reason, coil stock can continue to be made and reliable records obtained—which is essential to the continuation of normal business. Second, with all three or even two computers operating normally, the accumulation of spurious bits by one computer does not destroy the reliability of the printed record. These stray bits can occasionally be found in a computer. Their source is frequently unknown, and their occurrence is so infrequent and so random that the cure of the cause becomes a very irksome process. With the three-computer system, any required routine maintenance operations can be carried out during operation of the line without stopping the data accumulation. Finally, and probably of most importance, the three-computer system inspires complete confidence in the records at all levels of steel company managements, and their customers have quickly acquired this same confidence.

There are many applications of data accumulation in the various continuous process industries. The product and the important physical characteristics vary widely, in various processes, but the requirements of quality control, production control, pricing and other operations are such as to warrant the purchase and installation of some form of data accumulation equipment.

Some potential applications of these techniques include:

1. Electrolytic tinning lines.
2. Side trim and coil preparation lines.
3. Continuous annealing lines.
4. Plating and cladding lines. ▲

Rotary Hearth Furnace Promises Cokemaking Savings

A NEW technique employing a rotary hearth type furnace, similar to that used in metallurgical operations, has been developed for the continuous production of metallurgical grade coke. Requiring only about a quarter as much auxiliary equipment as other coking processes, the new process operates continuously instead of in batches—as in the beehive and by-product processes. Where desirable, the exhaust gases can be easily collected for processing into coal tar by-products. The ability to use low grade coals to produce low moisture content, high quality coke further enhances the economical factors relating to the rotary hearth furnace coke production method.

The development is the result of a cooperative effort between Salem-Brosius, Inc. and the New York Mining and Manufacturing Co. of New York City and Dorchester, Va. These firms, which have entered into a joint agreement to put the process into operation, will develop a pilot-type furnace immediately, and later will build units about 70-ft in diameter. The production goal for the 70 ft diam coking furnaces is about 5000 tons of high grade metallurgical coke per month, from approximately 8000 tons of coal. Because of the reduction in equipment requirements, such as coal crushing and cleaning, and coal preparation facilities, and the reduction in labor requirements, the cost per ton of produced coke is expected to be substantially lower than that of other processes now in use.

The pilot production unit will be erected at Dorchester, Va., and will be in operation late in 1960.

The rotary hearth type furnace is well known as an efficient, high production heating furnace in the metallurgical industry, where it is used for heating metal products for rolling, forging, and other processing. In adapting the principle for coke production, a deep bed of coal is fed onto the hearth, which rotates within the circular shell. Hot exhaust gases from high temperature zones in the furnace are directed to the zone immediately behind the feeding hopper, igniting the coal. Air, directed into the combustion zone through ports in the side of the furnace, supports combustion of the gases in the coal. As the furnace continues to rotate, the coking process progresses.

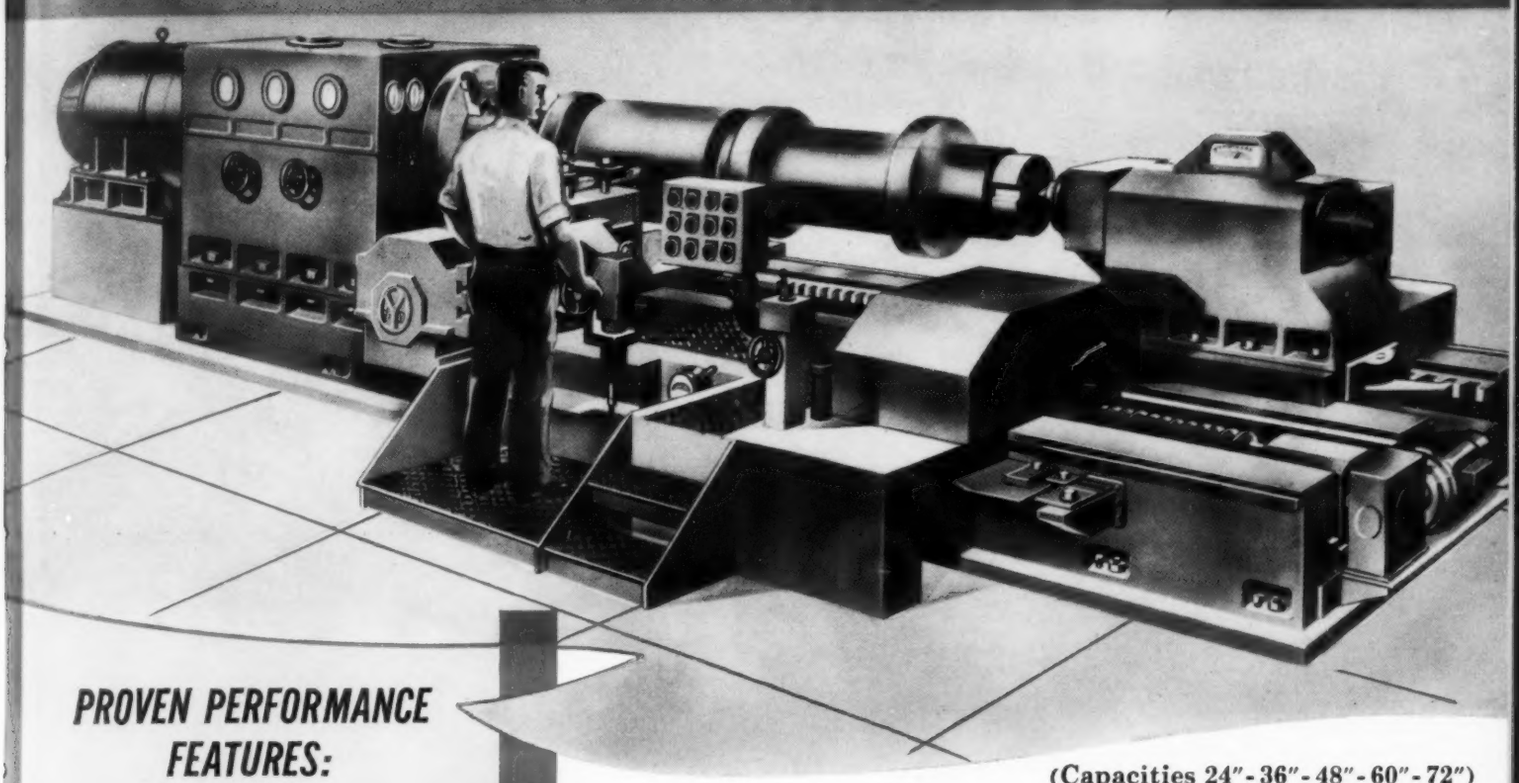
Upon completion of the coking process, the coke is withdrawn from the furnace and quenched. The entire coking is completed in one revolution of the furnace hearth. The process is autogenetic, in that no outside heat is applied to ignite the coal. Heat for starting combustion is applied to the coal from the high temperature zones of the furnace by piping exhaust gases from these zones to the ignition zone.

Recent research in the area of coke production has been the result of economics. Until early in the 1900's, coke was produced in beehive or rectangular coke ovens. With the advent of coal chemistry, the by-product type oven was developed, whereby the exhaust gases from coking were captured and processed into hundreds of coal tar chemicals such as benzol, toluol, pyridine, ammonium sulphate and other chemicals and pharmaceuticals. The recent decline in demand for such chemicals, because of competition from other sources, the high cost of installation of the by-product type oven, and smoke abatement programs in the various industrial areas of the country, have forced producers to seek other methods of coke production.

The new rotary hearth furnace method of coke production appears to be a major break-through, cost-wise, in the effort to produce high grade metallurgical quality coke. Because of the nature of the method employed, recovery of by-products from the exhaust gases is possible; and through the use of proper air cleaning equipment in conjunction with the process, the exhaust gases can be cleaned and released into the atmosphere with no danger of air pollution or violation of local ordinances pertaining to smoke control. ▲

FAR AHEAD IN DESIGN AND EFFICIENCY

"YOUNGSTOWN"
CONTOUR ROLL LATHES



(Capacities 24"-36"-48"-60"-72")

PROVEN PERFORMANCE FEATURES:

Heavy Duty roll lathe *rigidity*—with the *versatility* of the engine lathe

Use of carbide, or ceramic tools provided by wide RPM range of headstock speeds

3-Way bed for rigidity, with hardened and replaceable wear plates

Anti-Friction Ball screws and nuts for longitudinal travel of carriage and cross-slide insuring precision tracing

Operator travels with the work

Heavy-Duty spring-loaded tail stock with load indicator—safeguards bearings

Headstock has illuminated inspection ports, automatic lubrication, Timken roller bearings

Housings—manually or hydraulically operated

Electric-Hydraulic Ragging attachment optional

Heavy Duty mill type construction Herringbone gearing throughout

Faceplate overhang eliminated.

Automatic

"templet or numerically controlled" hydraulic or electric tracers assure fine finish and precision operation

Designed for a single purpose—roll turning. Choice of turning rolls in housings on the roll necks or using the heavy duty live centers provided in the headstock and tailstock.

"YOUNGSTOWN" engineering anticipates your future, as well as present productive position, in this quality line of Contour Roll Lathes.

Write us to arrange a demonstration.

The Youngstown Foundry & Machine Co.

Serving Industry Since 1885

Youngstown 1, Ohio

PENNSYLVANIA INTRODUCES THE

Loadmaster...

100

...to Give You Full Circuit Protection at up to 30% Less Cost

*Patents applied for

600-volt fused interrupter switch

The new Loadmaster 100*—another first from Pennsylvania—is a 600-volt load interrupter *specifically designed* to employ new current-limiting fuses in drawout switchgear. It combines the economy of a fused interrupter switch with the basic functions of a circuit breaker.

The Loadmaster 100:

Provides full overload protection with new Buss Low-Peak dual-element fuses

Provides complete major fault protection with current-limiting action within one-half cycle

Provides protection against single-phasing

Provides fully-rated systems at the price of cascaded systems

Extends economically the range of substation capacities . . . all this at a considerable savings in equipment cost—the exact amount of savings depending upon the particular application.

Complete Primary and Feeder Coordination

Overload and fault protection with the Low-Peak fuses will coordinate both with primary fuse protection and individual load controls (see fuse coordination curves). In the overload region the Loadmaster has adequate time delay, while under fault conditions the circuit is cleared well before peak current conditions are reached. A fault in any phase clears all three phases simultaneously, preventing single-phase operation.

Provides Fully-Rated System at No Increase in Cost

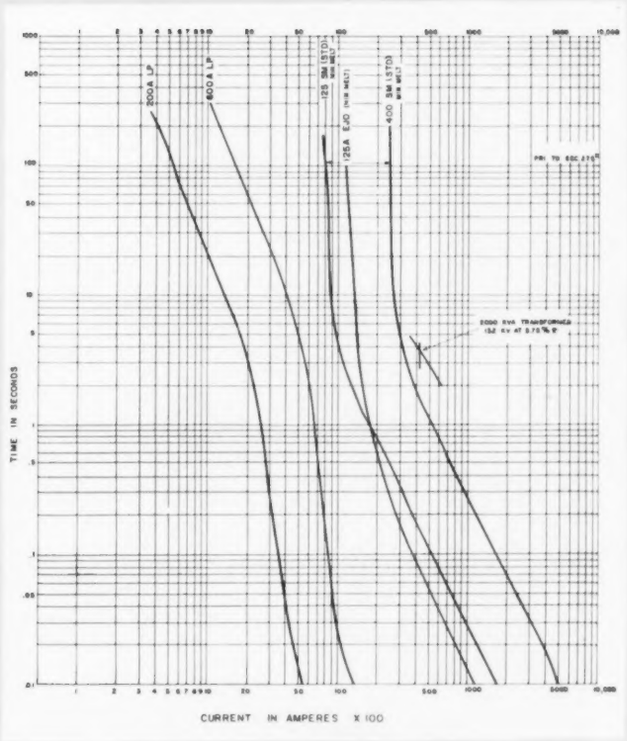
The Loadmaster 100 has an interrupting and close-in rating of 100,000 symmetrical amperes, confirmed by extensive tests at the Bussmann-Thos. A. Edison short-circuit laboratory. This rating makes it possible to provide the advantages of a fully-rated feeder system with the Loadmaster, at the cost of cascading.

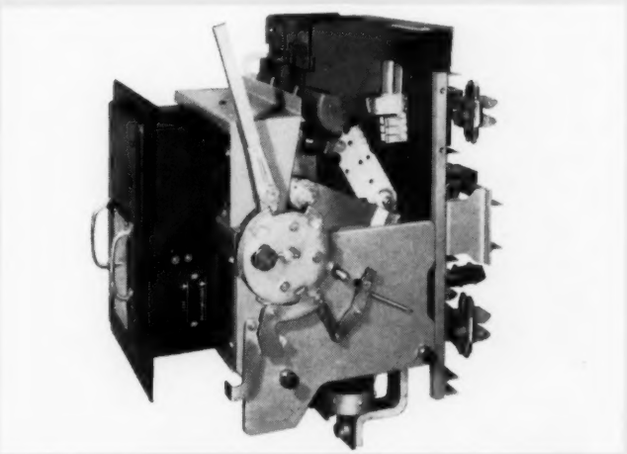
More Kva per Dollar

Larger substation ratings—at less dollar cost per kva—are possible with the new Loadmaster 100. Transformer cost per kva becomes less as the rating increases. Since the standard Loadmaster 100 can replace the large-frame circuit breakers required in systems capable of delivering up to 100,000 amperes, the often prohibitive switchgear cost involved in large substations is eliminated.

Other outstanding features of Loadmaster 100:

- Electrically-operated spring-charged close and trip
- Remote close and trip control
- Blade-type contacts which eliminate bounce
- No live parts on switch front—integrally-mounted fuses requires complete disconnecting from energized bus before inspection and replacement





Overload and fault coordination provided by the Loadmaster 100 are shown by the time-current values for 200-ampere and 600-ampere Low-Peak fuses (left). Low-voltage fuses are readily coordinated with transformer primary protective devices (right).

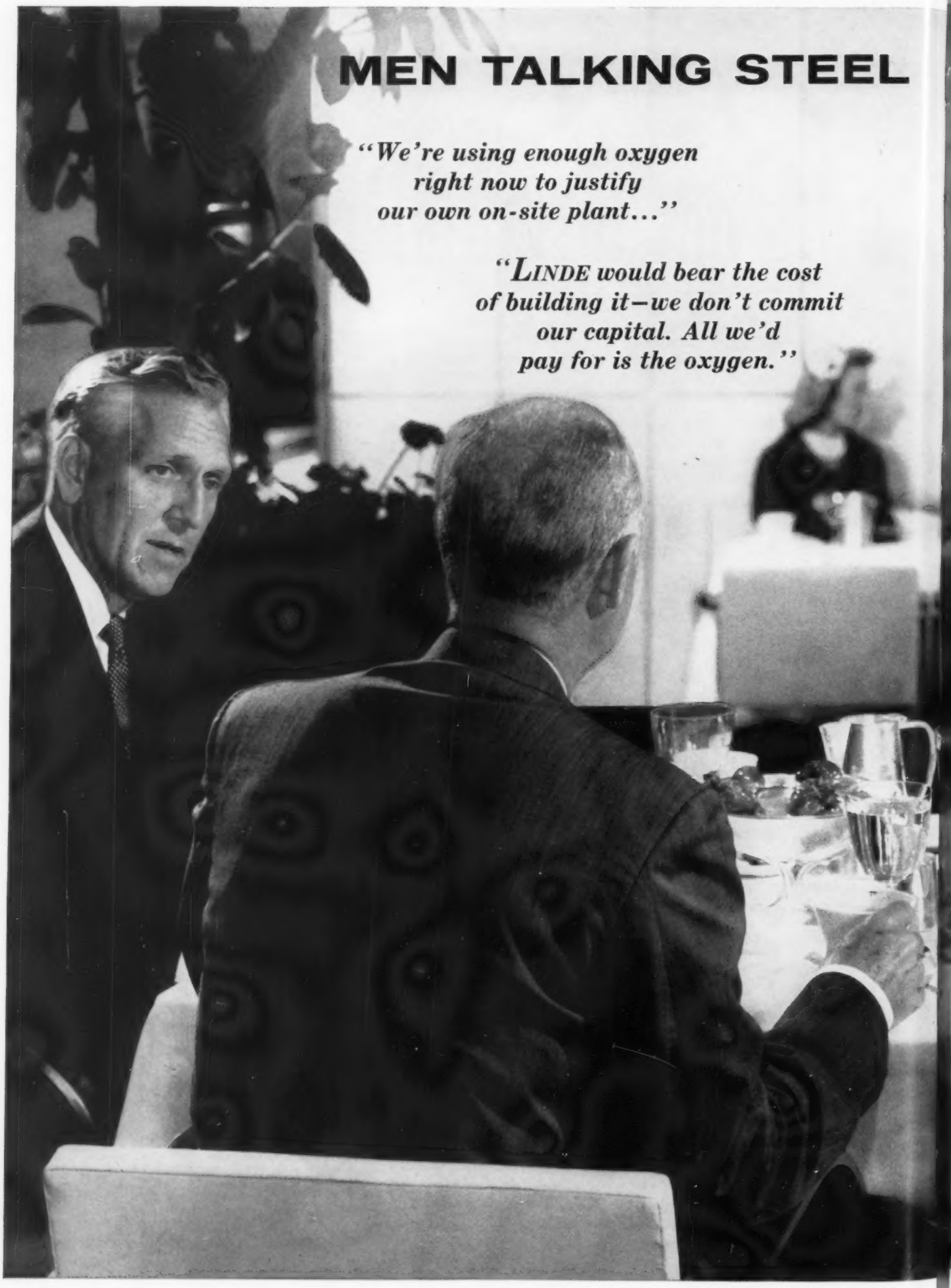
Side view of the Loadmaster 100 shows blade-type contacts. Phase barriers and arc chute at right have been removed.

Pennsylvania Unit Substations

PENNSYLVANIA TRANSFORMER DIVISION

McGRAW-EDISON COMPANY · CANONSBURG, PENNSYLVANIA

over 31 years' experience . . . builders of transformers from 5 to 500,000 kva; 24 to 460 kv


MEN TALKING STEEL
"We're using enough oxygen
right now to justify
our own on-site plant..."
"LINDE would bear the cost
of building it—we don't commit
our capital. All we'd
pay for is the oxygen."

ARE TALKING LINDE OXYGEN

"With several times the back-up capacity of anyone else, LINDE can always meet emergency calls too."

"More reasonable than I expected."

To get the full set of facts on how LINDE applies *total gas technology* to on-site plants for the steel industry, write Linde Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. *In Canada*, Union Carbide Canada Limited, Linde Gases Division, Toronto 12.

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new combination... new results...

GENERAL REFRACTORIES

GREFCO

"A COMPLETE REFRACTORIES SERVICE"

GREFCO HI-SIL

from a new semi-silica brick...

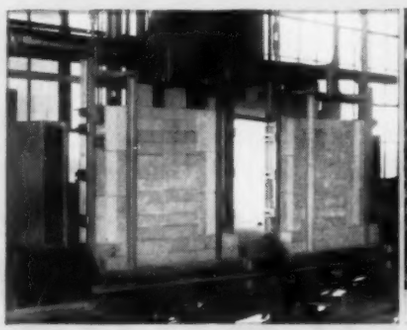
HI-SIL is a new blend of pure washed silica rock and calcined high purity kaolin. This combination and GREFCO's controlled manufacturing methods combine to make HI-SIL's exceptional effectiveness in such areas as walls and roofs in reheating furnaces, regenerator roofs and fan-tail arches in open hearths, checkers, walls and domes in blast furnace stoves, and in many parts of ceramic kilns.

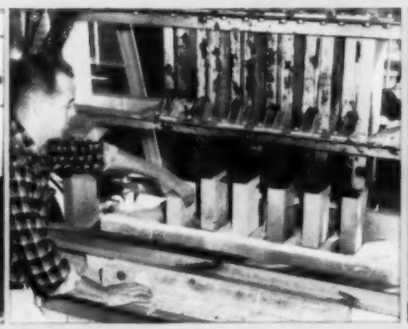
HI-SIL has been tested . . . and these are the results . . .

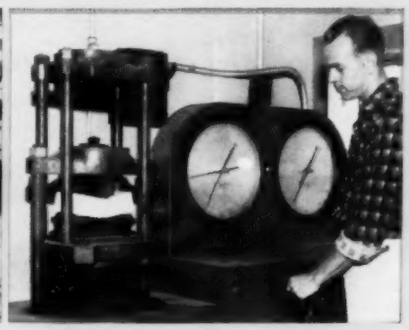
1. Thermal Spalling Resistance HI-SIL showed less than 1.0% weight loss after being heated to 2700°F and then being subjected to 12 heating and 12 cooling cycles! Cold water spray was used for rapid cooling.

2. Resistance to Hot Load Deformation HI-SIL was heated to 2400°F under a load 25 pounds per square inch and held under those conditions for 336 hours. The brick showed no subsidence. Actual result was slight expansion.

3. High Modulus of Rupture HI-SIL typically has a modulus of rupture of 400 psi. This provides superior resistance to cold loads and damage from shipment, handling and placement.







Complete information on HI-SIL, manufactured at GREFCO's Warren, Ohio Works, is available from your nearest GREFCO representative. Or please write us at our general office.

GENERAL REFRACTORIES COMPANY

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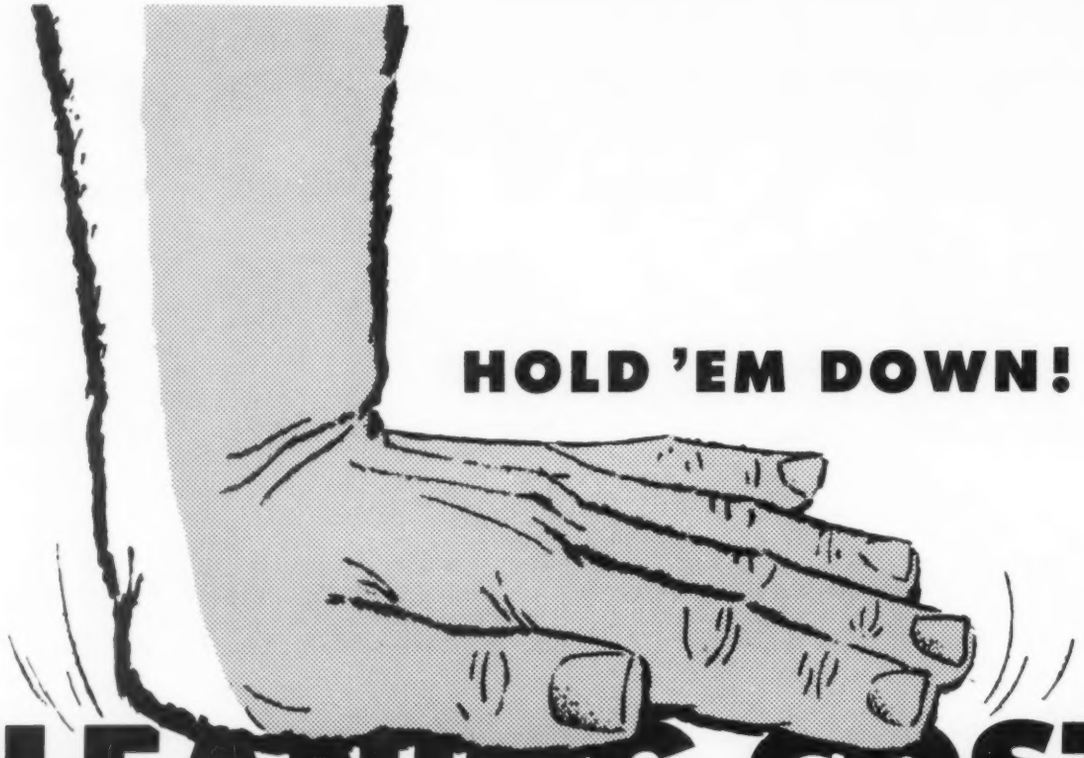

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CLEANING COSTS

Now, there's a *new* and *dependable* way to reduce cleaning costs — without sacrificing cleaning efficiency! For METAL BLAST has an entirely new and more economical process* for making steel abrasives — and passes the savings along to consumers.

Now, you can make substantial savings on cleaning or descaling costs simply by changing over to "SUPER-STEEL" steel shot and grit. At $165.00 per ton, you'll really save money! And, you'll still enjoy fast and thorough cleaning, low abrasive consumption and low maintenance costs. As a matter of fact, "SUPER-STEEL" is *guaranteed* to equal the performance of any other steel abrasive.

Consider what you're now paying for steel abrasives — probably upwards of $200.00 per ton! Why pay this high price, when new "SUPER-STEEL" costs so much less? Why not check this new, economical abrasive? Write, wire or phone collect for test samples.

*PATENTS APPLIED FOR

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MANUFACTURERS, ALSO, OF TOP QUALITY "SEMI-STEEL" SHOT AND GRIT, MALLEABLE AND CHILLED SHOT AND GRIT — AT COMPARABLE SAVINGS!

"SUPER-STEEL"

STEEL SHOT *and* GRIT

$165.00 *per ton in truck loads*

Date-line Diary...

September 1

Δ American Iron Ore Assn. reports that shipments of iron ore down the Great Lakes in August, 1960, totaled 10,017,693 gross tons compared with 817,520 gross tons in August, 1959.

Δ The Census Bureau reported that the value of new construction put in place in August, 1960, dropped to a seasonally adjusted annual rate of $54,500,000,000, down one per cent from July, 1960, and five per cent lower than in August, 1959.

Δ A three-year contract offered by the General Electric Co. to its unionized employees, providing an immediate three per cent wage increase, a four per cent wage increase in April, 1962, and broadened benefits in other areas, effective October 1, 1960, at the expiration of the present five year contracts, was rejected by the A.F.L.-C.I.O. International Union of Electrical Workers and the independent United Electrical Workers.

Δ Output at Sharon Steel Roemer works in Farrell, Pa., was halted by a wildcat strike of about 100 electrical maintenance workers, idling about 1500 nonstriking workers.

Δ American Iron Ore Assn. and AISI joint reports show receipts of iron ore in the United States for July, 1960, amounted to 15,705,014 gross tons, compared with 9,907,445 in July, 1959. Consumption in 1960 to July 31, amounted to 70,228,774 compared with 71,202,474 gross tons to July 31, 1959. Blast furnaces in operation on July 31, 1960, totaled 138 of the existing 258. On July 31, 1959, 73 blast furnaces were in operation.

September 2

Δ Operation was resumed at Sharon Steel Roemer Works when 150 striking electricians agreed to return to work on a promise that negotiations would start at once on their grievances.

Δ AISI reports that the steel industry's employment of hourly and salaried workers in July, 1960, totaled 554,069. The payroll for hourly and salaried workers combined for July, 1960, totaled $286,967,361. Hourly rate in July was $3.675. Average hours per week worked were 31.9 in July, 1960.

Δ The Bureau of the Census reports that shipments of iron and steel castings in June, 1960, totaled 1,259,225 short tons compared with 1,248,320 tons in May, 1960, and 1,480,406 tons in June, 1959.

Δ The Bureau of the Census reports that shipments of nonferrous castings in June, 1960, totaled 180,172,000 lb compared with 181,361,000 lb in May, 1960.

September 5

Δ The AISI reports that the operating rate of the steel industry for the week of September 5 is scheduled at 1,441,000 tons (50.6 per cent of capacity). This compares with 1,483,000 tons one week ago (52.0 per cent capacity) and 327,000 tons one year ago. Index of production for the week is 89.7.

September 6

Δ The Commerce Dept. reported that business sales in July, 1960, declined to a seasonally adjusted $61,000,000,000, down $800,000,000 from June, 1960, and $700,000,000 from July, 1959. Manufacturers inventories on July 31 totaled $93,300,000,000, down $100,000,000 from June, 1960. Retail inventories at July 31, 1960, amounted to $25,400,000,000, up $100,000,000 from June 30, 1960.

Δ The U. S. Dept. of the Interior, Bureau of Mines, reports that production of Pennsylvania anthracite in August, 1960, totaled 1,590,000 net tons, compared with 1,140,000 net tons in July, 1960, and 1,600,000 net tons in August, 1959.

September 8

Δ The AISI reported that shipments of finished steel products from mills during July, 1960, totaled 4,710,565 net tons, compared with 5,920,860 tons in June, 1960, and 4,131,267 tons in July, 1959.

Δ Auto sales in August, 1960, totaled 479,100 U. S.-built cars, compared with 485,000 cars retailed in August, 1959.

Δ Keystone Steel and Wire Co. reports for the fiscal year ending June 30, sales of $128,840,899, net profits of $8,320,490 equal to $4.44 per share compared with sales in 1958 totaling $120,071,295, net income amounting to $9,075,374 equal to $4.84 a share.

Δ The Bureau of Statistics (Canada) reports that output of pig iron in Canada in August, 1960, totaled 329,805 tons, compared with 359,179 tons in August, 1959; steel production in August, 1960, totaled 425,327 tons compared with 477,790 tons in August, 1959.

September 9

Δ The Dept. of the Interior, Bureau of Mines, reports that 412,000,000 tons of bituminous coal and lignite were produced in the U. S. in 1959, less than one-half of one per cent increase over 1958 output.

September 12

Δ The Labor Dept. reported that employment in mid-August, 1960, totaled 68,282,000 a drop of 407,000 from mid-July, 1960.

Δ The Commerce Dept. reported that retail sales in the U. S. in August, 1960, amounted to a seasonally adjusted $18,200,000,000, about unchanged from July, 1960.

Δ The AISI reports that the operating rate of the steel industry for the week of September 12, is scheduled at 1,503,000 tons (52.7 per cent of capacity). This compares with 1,401,000 tons one week ago (49.2 per cent capacity) and 356,000 tons one year ago. Index of production for the week is 93.6.

September 13

Δ Directors of Algoma Steel Corp. Ltd., approved amalgamation with the parent company of two wholly owned subsidiaries, Algoma Ore Properties, Ltd. and Canadian Furnace Co., Ltd. The two subsidiaries will become divisions.

Δ The Pennsylvania Railroad and the striking unions terminated the strike which caused the first complete closedown of the road in its 114-year history.

Δ The AISI reports that the steelmaking furnaces in the U. S. in August, 1960, poured 6,836,000 net tons of ingots and steel for castings, compared with 6,350,924 tons in July, 1960, and 1,439,277 tons in August, 1959.

△ The Bureau of the Census reports that shipments of commercial steel forgings in July, 1960, totaled 79,258 short tons compared with 110,051 tons in June, 1960, and 101,521 tons in July, 1959. Unfilled orders at the end of July, 1960, totaled 295,239 tons compared with 295,238 tons in June, 1960, and 374,457 tons in July, 1959.

September 15

△ The Commerce Dept. reported that personal income in August, 1960, was at a $407,600,000,000 annual rate, an increase of $300,000,000 over July, 1960. For August, 1959, the pace was $383,300,000,000.

△ The Bureau of the Census reported that net shipments of aluminum pig and ingot in July, 1960, totaled 102,790,000 lb, compared with 132,823,000 lb in June, 1960, and 136,279,000 in July, 1959. Shipments of aluminum mill products in July, 1960, totaled 250,970,000 lb. compared with 278,329,000 lb in June, 1960, and 373,090,000 in July, 1959. Shipments of magnesium mill products in July, 1960, totaled 1,526,000 lb compared with 1,742,000 lb in June, 1960, and 1,681,000 lb in July, 1959.

September 16

△ Stainless steel prices have been lowered 2½ to 3¢ per lb, about 4.8 to 6 per cent by major producers on items equalling about 15 to 17 per cent of total volume.

September 19

△ The AISI reports that the operating rate of the steel industry for the week of September 19, is scheduled at 1,537,000 tons (53.9 per cent of capacity). This compares with 1,510,000 tons one week ago (53.0 per cent capacity) and 362,000 tons one year ago. Index of production for the week is 95.7.

September 20

△ Dow-Jones industrials dropped 15.42 points (2.56 per cent) to 586.76, sharpest break in almost five years.

△ The Census Bureau reported that private housing starts in August, 1960, ran at a seasonally adjusted annual rate of 1,275,000, 8 per cent over July, 1960, but 12 per cent lower than August, 1959.

△ David J. McDonald said the USW will "go to congress" next year with a proposal to enact a 32-hr week for all basic industries.

△ SEC reported that net savings in the U. S. fell to $1,000,000,000 in the second quarter of 1960 compared with $4,300,000,000 in the first quarter of 1960, and $2,900,000,000 in the second quarter of 1959. A $5,000,000,000 increase in individual debt occurred in the second quarter.

△ The Bureau of the Census reported that titanium mill products in July, 1960, totaled 623,991 lb compared with 903,620 lb in June, 1960, and 362,860 lb in July, 1959.

September 21

△ The ARCI reported that deliveries of new freight cars in August, 1960, totaled 4124 compared with 3893 in July, 1960, and 4890 in August, 1959. New orders in August, 1960, totaled 1343 cars compared with 1306 in July, 1960 and 1753 in August, 1959. Backlog of cars on order as of September 1, 1960, totaled 23,866, compared with 26,658 on August 1, 1960, and 37,172 on September 1, 1959.

△ It was reported that the USW plan a major overhaul in its system of health and medical care insurance established by contract with steel producers. The present system costs the steel companies $134,000,000 annually and the study reported contended the union did not get enough for its money.

September 22

△ The High Authority of the European Coal and Steel Community filed a registration statement with the SEC covering a proposed public offering of $35,000,000 of new securities which will include $25,000,000 of secured bonds, due 1980, and $10,000,000 of secured notes due 1963–65. Proceeds from the sale will be used for various operations by the Community.

△ The Bureau of Mines reported that consumption of scrap in the United States in July, 1960, totaled 3,687,000 gross tons, compared with 4,485,444 tons in June, 1960; consumption of pig iron in the U. S. in July, 1960, totaled 3,889,000 gross tons compared with 4,691,902 tons in June, 1960.

September 23

△ Gold holdings in the U. S. Government fell $181,000,000 in the week ended September 21, reducing the total to $18,700,000,000, lowest since April, 1940.

△ The Aluminum Assn. reports that production of primary aluminum in the United States in August, 1960, totaled 172,973 short tons compared with 177,564 tons in July, 1960, and 172,817 tons in August, 1959.

September 24

△ The Japan Iron & Steel Federation reports that in August, 1960, production of pig iron amounted to 1,122,000 net tons, production of crude steel totaled 1,998,000 net tons.

△ The Bureau of Statistics reported that production of steel in Canada in the week ended September 24, totaled 109,895 tons (85.1 per cent capacity) compared with 109,451 tons in the previous week, and 115,699 tons in the like week of 1959.

△ Northwestern Steel and Wire Co. reports for the fiscal year ended July 31, 1960 sales totaled $67,258,342, net income $5,873,265, or $2.35 per share compared with sales totaling $83,781,108, net income of $8,450,321 or $3.38 per share in 1959.

September 26

△ The AISI reports that the operating rate of the steel industry for the week of September 26 is scheduled at 1,545,000 tons (54.2 per cent of capacity). This compares with 1,547,000 tons one week ago (54.3 per cent capacity) and 362,000 tons one year ago. Index of production for the week is 96.2.

△ The AISC reports that shipments of fabricated structural steel in August, 1960, totaled 331,932 tons compared with 301,249 tons in July, 1960, and 220,420 tons in August, 1959. Bookings for August, 1960, totaled 261,976 tons compared with 270,198 tons in July, 1960, and 196,985 tons in August, 1959. Backlog as of August 31, 1960 amounted to 2,114,179 tons.

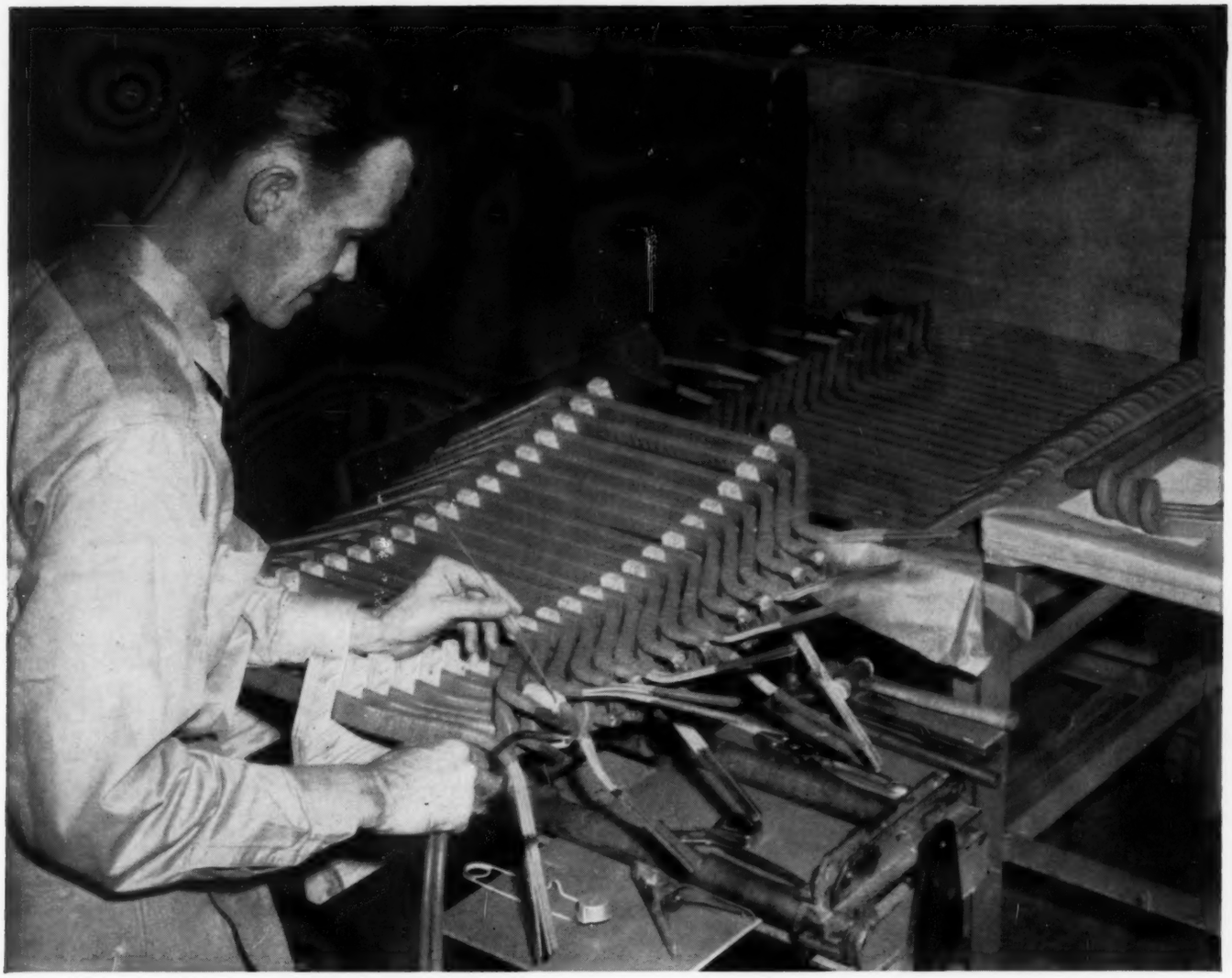
△ The Labor Dept. reported that consumer prices in August held at 126.6 per cent of the 1947–49 average, unchanged from the July level.

△ The Commerce Dept. estimates that investments overseas by American companies in 1960 will amount to about $2,000,000,000, down from $2,400,000,000 total in 1959.

September 29

△ National Machine Tool Builders Assn. reports that new orders in August, 1960, totaled $57,550,000 compared with $42,950,000 in July, 1960. Shipments in August, 1960, totaled $47,150,000 compared with $51,300,000 in July, 1960.

△ Government figures showed that U. S. exports in August declined to $1,600,000,000 down 5 per cent from July, 1960, but 16 per cent over August, 1959.



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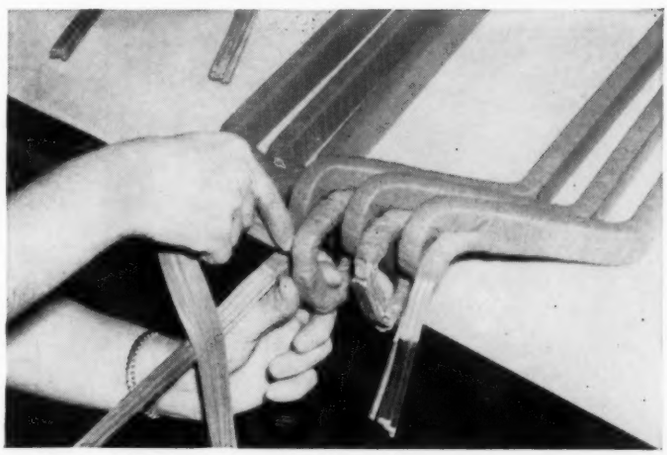

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The drawing below shows how the BLOOM RADIANT TUBE BURNER can be mounted on the tube outside of the furnace, without danger of tube overheating. Nozzle is at inside edge of furnace wall. Design provides uniform tube temperature without hot spots, regardless of flow. Recuperator preheats air 600° to 800°F. Operates on clean or dirty coke oven gas, natural gas or butane. Continuously burning pilot assures positive ignition.

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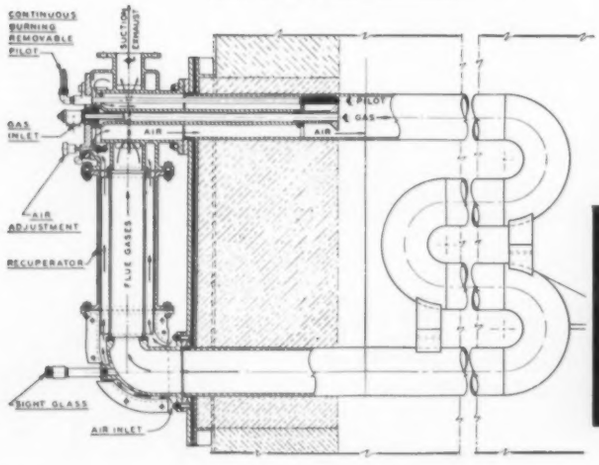

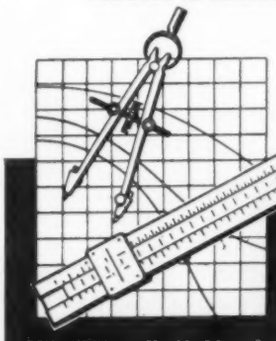

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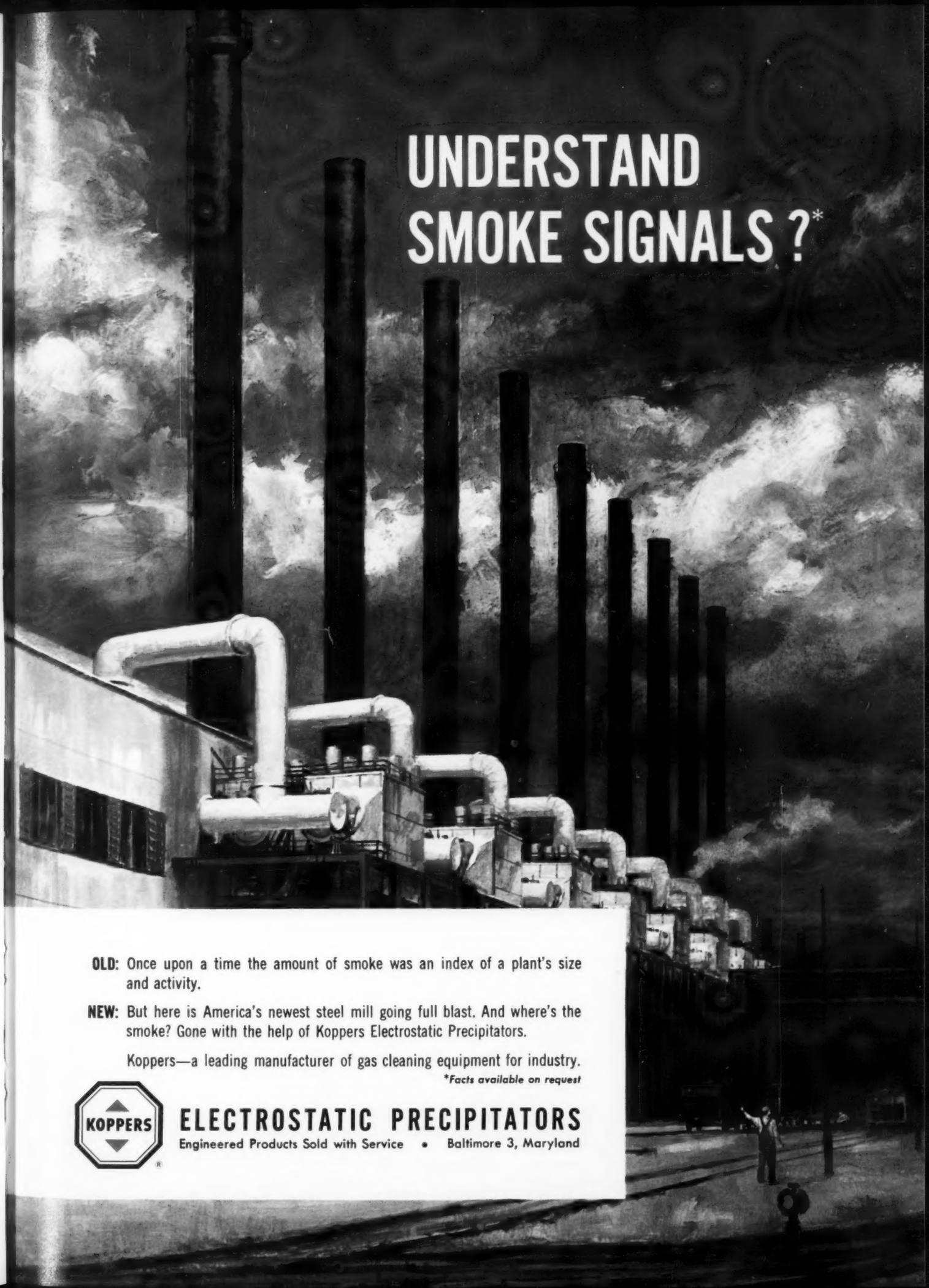

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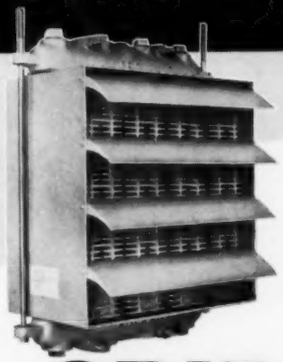

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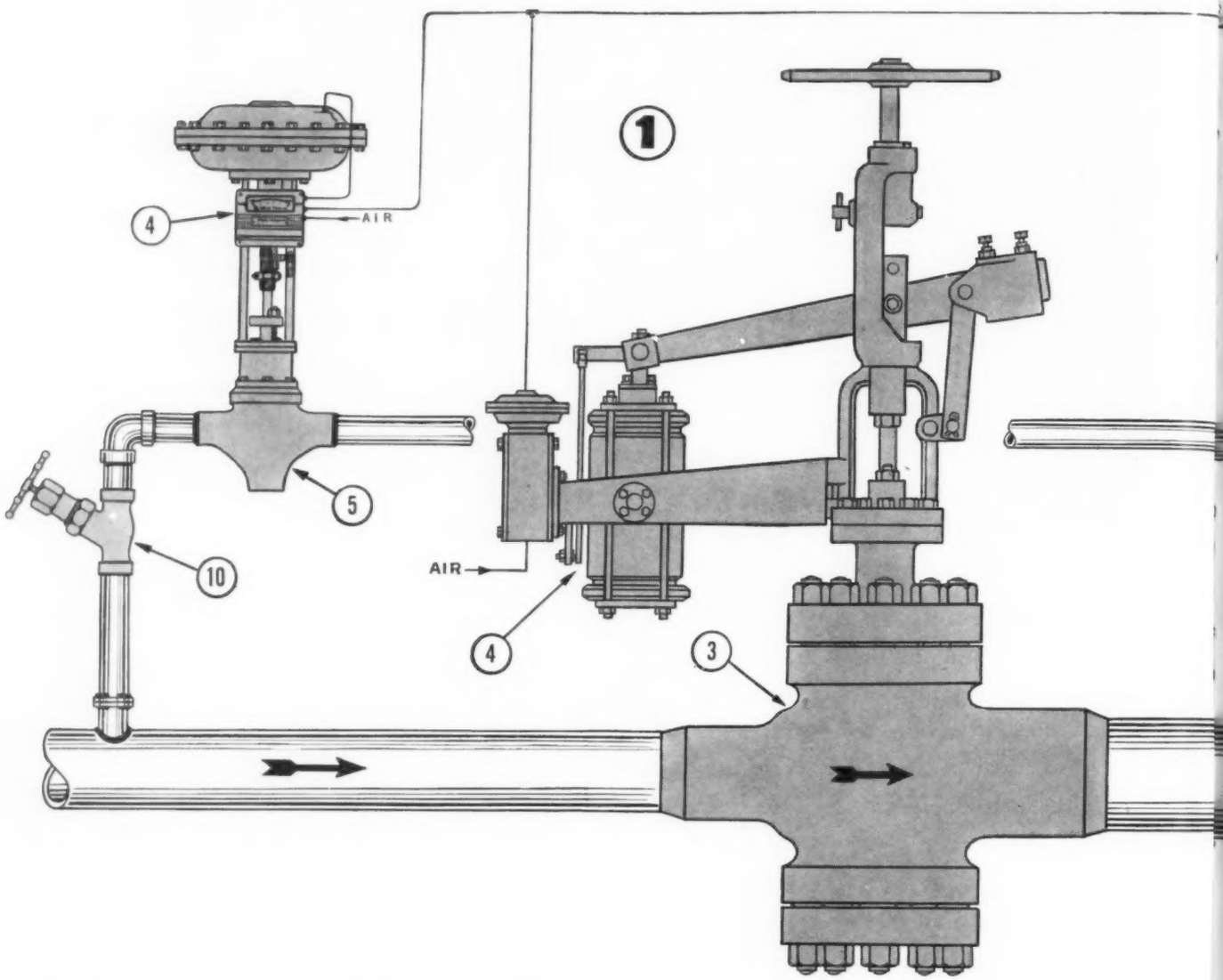

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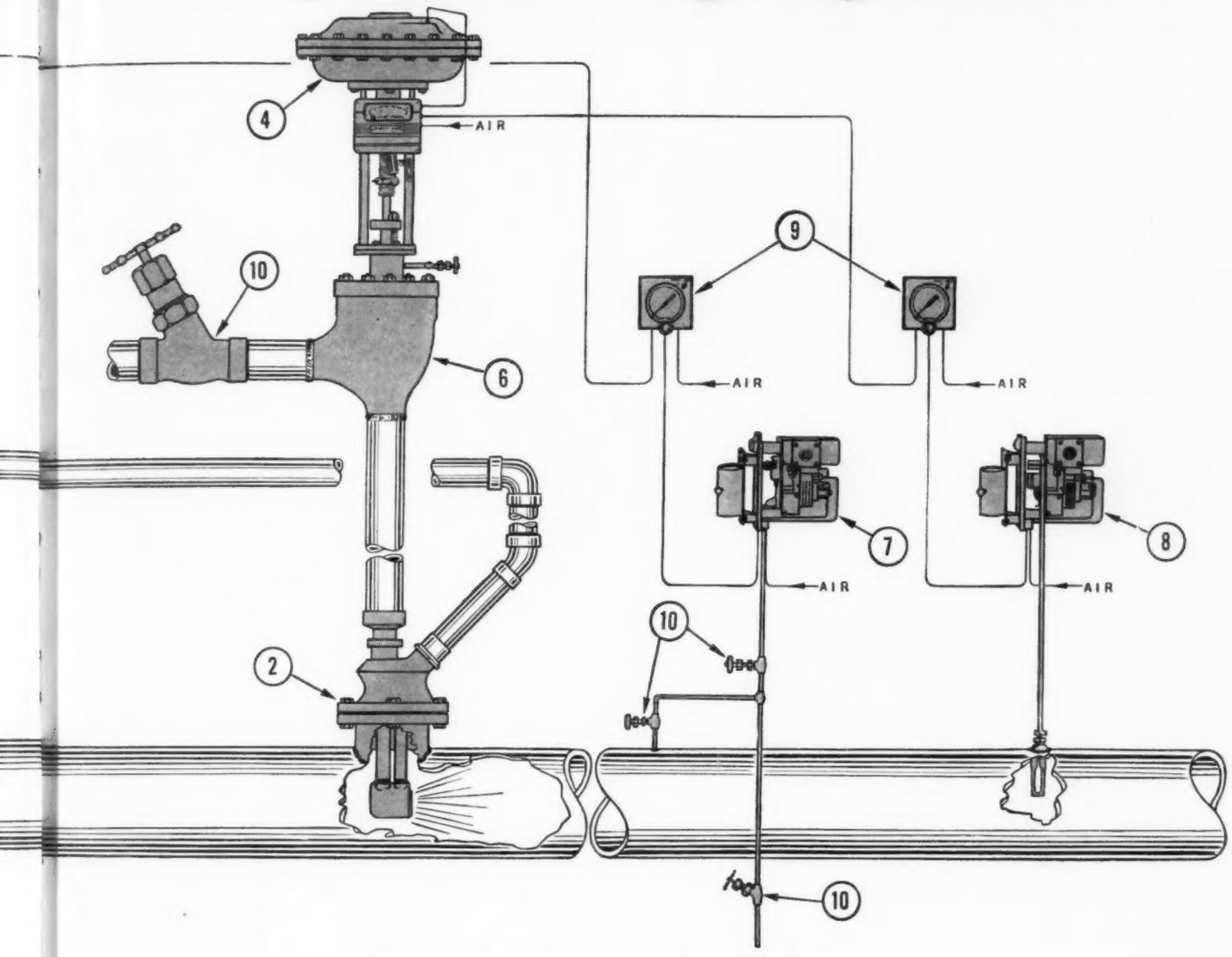

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Industry News...

CHICAGO HEIGHTS PLANT COMPLETES EXPANSION

△ Completion of an extensive 18 month modernization and expansion of Inland Steel Co.'s Chicago Heights Works has been announced.

The plant has been completely revamped and is now the largest and most up-to-date mill of its type in the country, according to F. M. Rich, vice president in charge of steel manufacturing.

Output of the Chicago Heights plant includes concrete reinforcing bars, fence posts, sub purlins, merchant bars, automobile bumper brackets, jacks and special sections for agricultural implements.

The plant's capacity has been boosted 75 per cent from 80,000 to 140,000 tons a year. It has also been repowered and re-equipped to produce more merchant bar products from billets, adding to the capacity of Inland's merchant mills at its Indiana Harbor works.

Major changes made in the mill include installation of a reheating furnace to replace a smaller one, addition of new rolling stands with electronic controls, separate power installations to enable the plant's three rolling mills to operate faster, expansion of the electrical power and water distribution system, and extensions of the rolling mill building, and shipping department to house the additional equipment.

J&L ADDS NEW CRUSHERS AT BY-PRODUCT UNITS

△ New coal crushing equipment, the first of its type ever utilized for this application in the steel industry, has been installed by Jones & Laughlin Steel Corp. at both its Aliquippa and Pittsburgh Works.

The new equipment—Hazemag impact crushers—has been installed at the By-Product Coke Departments in the two plants as part of a coal beneficiation program which can produce 90 to 95 per cent of ⅛-in. mesh coal for charging into the coke ovens. This in turn will produce a stronger coke and result in improved performance for J&L's blast furnaces.

In addition to the new crushers, the installation includes blending facilities for mixing of high and low volatile coals, and also sampling facilities.

Rated capacity of the new equipment will be in excess of 3,500,000 tons per year, ample for J&L's coking requirements.

The Hazemag crushers, developed in Germany, first were utilized in the United States three years ago in the asbestos and limestone industries.

The crushers—two identical models—are located in the immediate vicinity of the coal unloading equipment both at Pittsburgh and Aliquippa. Coal is unloaded from barges, fed into the crusher, measured and then blended before it is charged into the coke ovens.

The new equipment replaces two older hammer-type crushers which are being converted into blenders. The older equipment provided coal up to 1 in. in size with 55 to 60 per cent through a ⅛-in. screen.

Other phases of the proposed program will include reduction of sulphur and ash in the coal, and maintenance of bulk density by the addition of either oil or water.

NEW RUSSIAN BLAST FURNACE IN OPERATION

The first blast furnace of the U.S.S.R.'s Karaganda Metallurgical Works began producing pig iron on July 2.

NEW GRANITE CITY MILL TO ROLL THIN TINPLATE

△ The Granite City Steel Co. has announced plans to produce both the standard and very thin gages of tinplate on a 6400 hp Sendzimir cold strip mill that is now being built and will go into production in the second quarter of 1961.

Meanwhile, arrangements have been made for production tests of thin tinplate produced by Sendzimir mill rolling on a unit operated by another steel company that does not produce tinplate. Coils of steel that have been partly reduced in thickness on Granite City Steel's 4-stand cold strip mill will be further

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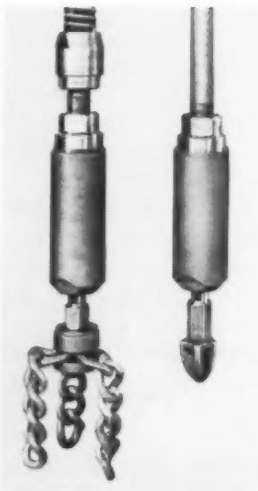
ELLIOTT TUBE CLEANER

Substantial saving of time and labor, and thorough cleaning of passages without harm to brickwork are effected through the use of standard Elliott tube cleaner air motor with the special whirling chain head illustrated at the right. If stubborn deposits require drilling, the same motor can be equipped with an extension piece and drill. The photographs above show how effectively square corners are cleaned. Many steel mills report savings in manhours as high as 50 percent with use of the Elliott checkerwork cleaners. Write for complete details.



Motor with chain head (left) and with drill and extension piece

ELLIOTT Company
Lagonda Plant • Springfield, Ohio

YO-1

reduced on the other company's Sendzimir mill to the very thin tinplate gages—down to 0.0044 of an inch in thickness.

The Sendzimir-reduced coils of steel will be tested by various can manufacturers. The steel will be fabricated and soldered into cans on their high-speed forming equipment.

Granite City Steel has engaged in experimental work with very thin tinplate since mid-1957, when some of the company's coils of cold rolled steel were further reduced in thickness on a Sendzimir mill. This product yielded satisfactory results in laboratory tests conducted in 1958 by one of the large can manufacturers.

About a year ago the company ordered the most powerful Sendzimir mill yet designed from the Waterbury Farrel Foundry and Machine Co., a division of Textron Inc. This mill is designed to handle wide cold rolled sheets at speeds of up to 3500 fpm. It is to be delivered to Granite City Steel next month.

Granite City's new mill will take coils of full-hard steel, 0.015 of an inch thick, from the company's cold strip mill, and reduce it to the desired tinplate thickness in one pass. It is expected that most of the company's tinplate steel will be rolled on the Sendzimir mill once it is in operation.

SHIP BIG LADLES FOR NEWEST SWEDISH MILL

△ The largest steel ladles ever built in Sweden, each weighing 34 tons and designed for a capacity of 180 tons of steel, have been delivered by Motala Verkstad, in western Sweden, to the new steelworks of the Grängesberg Company at Oxelösund on the Baltic Coast, south of Stockholm.

Too heavy to be transported by road or rail, the ladles were shipped onboard a freighter to their destination. The ladles are intended for tapping steel from an open-hearth furnace, the biggest of its kind in Sweden, into chills. The units have been designed with a view of making possible an increase in the steel capacity to 200 tons.

Further orders from Oxelösund for Motala Verkstad include ten mobile 90-ton ladles, each weighing 23 tons plus 24 tons for the carriage, for transporting pig iron from the

At Burnside Terminal . . .

Fast, efficient ship-to-barge bulk cargo transfer effects big savings for plants on inland waterways

A deep-water port facility, Burnside Terminal, Burnside, La., is a two-way transportation center for ocean-going vessels and river barges. Heavy bulk materials such as iron ore, manganese, bauxite, phosphate rock, coal, raw sugar, etc. can be transferred from ship to barge, barge to ship, ship or barge to storage, or from storage to ship or barge. As a result, plants located on the Mississippi River System can benefit from lower material costs and inexpensive barge transportation.

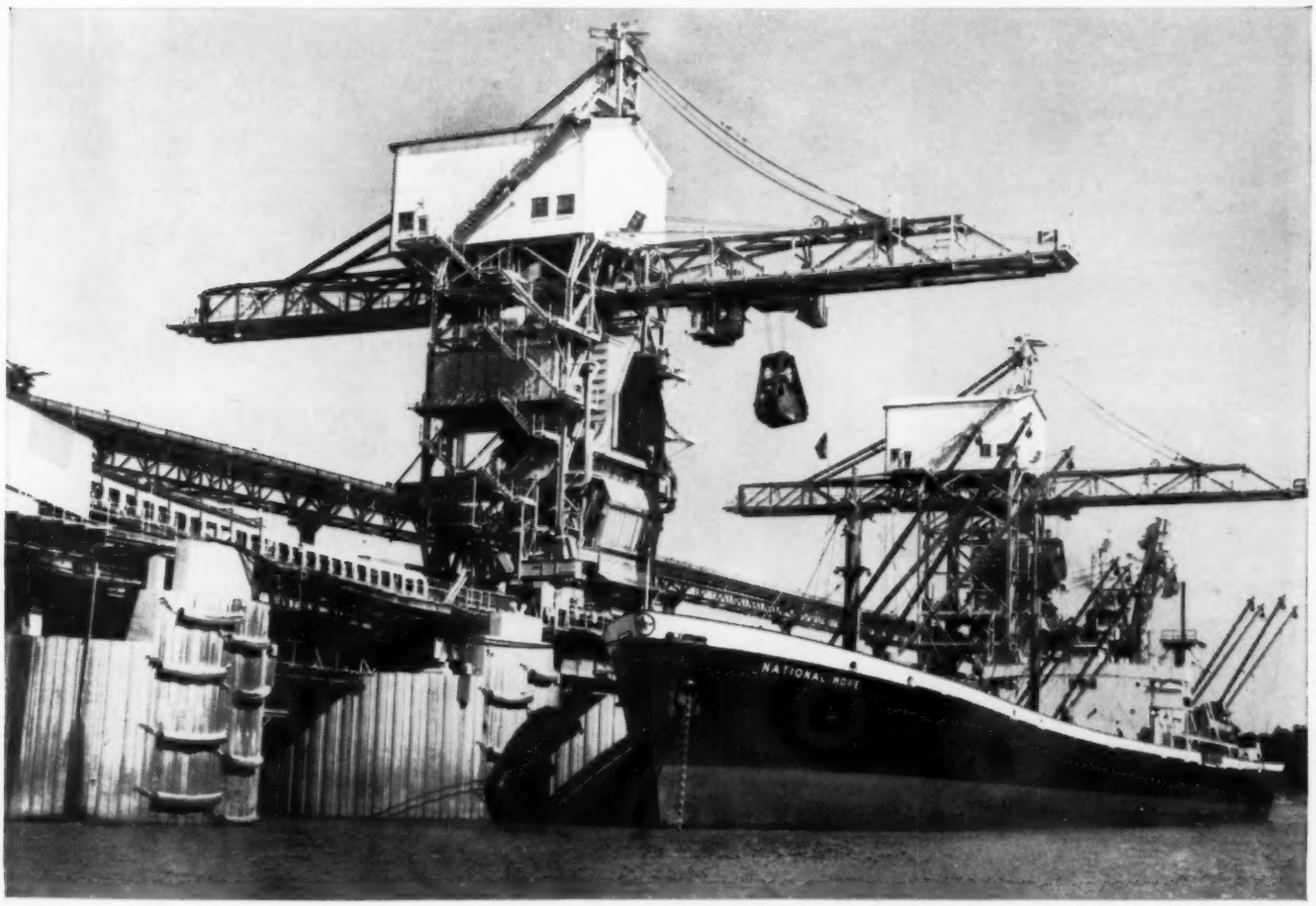
According to Captain H. O. Hall, assistant vice president of Ramsay, Scarlett & Co., Inc., operators of the terminal, the satisfactory performance of Dravo unloaders has been a major factor in providing this efficient, low-cost bulk cargo handling. Captain Hall puts it this way:

"Our Dravo unloaders help us substantially in assuring fast ship turn-around time.

"These cranes have lived up to the representations of the manufacturer. In fact, at times the free-digging performance in connection with bulk carriers has exceeded rated capacity.

"Because of the variety of bulk commodities handled here, speed in changing from one size of bucket to another is extremely important. With the new design of the Dravo unloader, the time required to change buckets generally is a matter of minutes."

This is typical of the benefits so many companies are getting with Dravo materials handling equipment. May we discuss your requirements with you? Write Dravo Corporation, Pittsburgh 25, Pennsylvania; or phone SPalding 1-1200.



Strategically located on the lower Mississippi River, Burnside Terminal provides an efficient facility for the transfer of bulk cargoes from ocean vessel and river barge. This is the most successful installation of this type now operating on the Mississippi.

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blast furnace to the steel works, and five 120-ton and three 100-ton ladles for transporting steel from mixer to furnace or converter.

DRAVO WILL INSTALL ASHLAND ORE BRIDGE

△ A 15-gross-ton man trolley ore bridge, serving enlarged ore storage facilities at the Ashland, Ky., works of Armco Steel Corp., will be designed and erected by Dravo Corp.

Armco is installing the stocking and reclaiming bridge and widening and lengthening the ore yard as part of a continuing expansion program begun several years ago.

Size of the bridge was determined by the projected size of the ore yard. The bridge will have a 300-ft span, and the man trolley will operate 90 ft above the base of the ore pile.

Quick loading of the blast furnace ore transfer cars is assured through the use of a 60-ton hopper attached to the shear leg of the bridge. The bucket will shuttle back and forth loading the hopper while the transfer car is on its way to the blast furnace, so that the hopper will be full when the transfer car returns.

Legs, trucks, trolley and equipment houses of the bridge will be of welded steel construction. A major safety factor will be the four Dravo spring-set, hydraulically-operated rail clamps, one for each of the four rails. These will automatically engage when wind velocity reaches 35 miles an hour or if power fails.

Driven by adjustable voltage d-c motors, the bridge will operate from a high voltage a-c power supply. Four 2-ft-stroke hydraulic buffers, two at each end of the trolley runway, will insure safe stops of the man trolley.

LIGHTWEIGHT TINPLATE SHIPPED COMMERCIALLY

△ U. S. Steel Corp.'s new thinner tinplate called "Ferrolite," announced in the pilot stage last January, is now commercially available in weights of 45 through 60 lb per base box, according to an announcement by Leslie B. Worthington, president of the corporation.

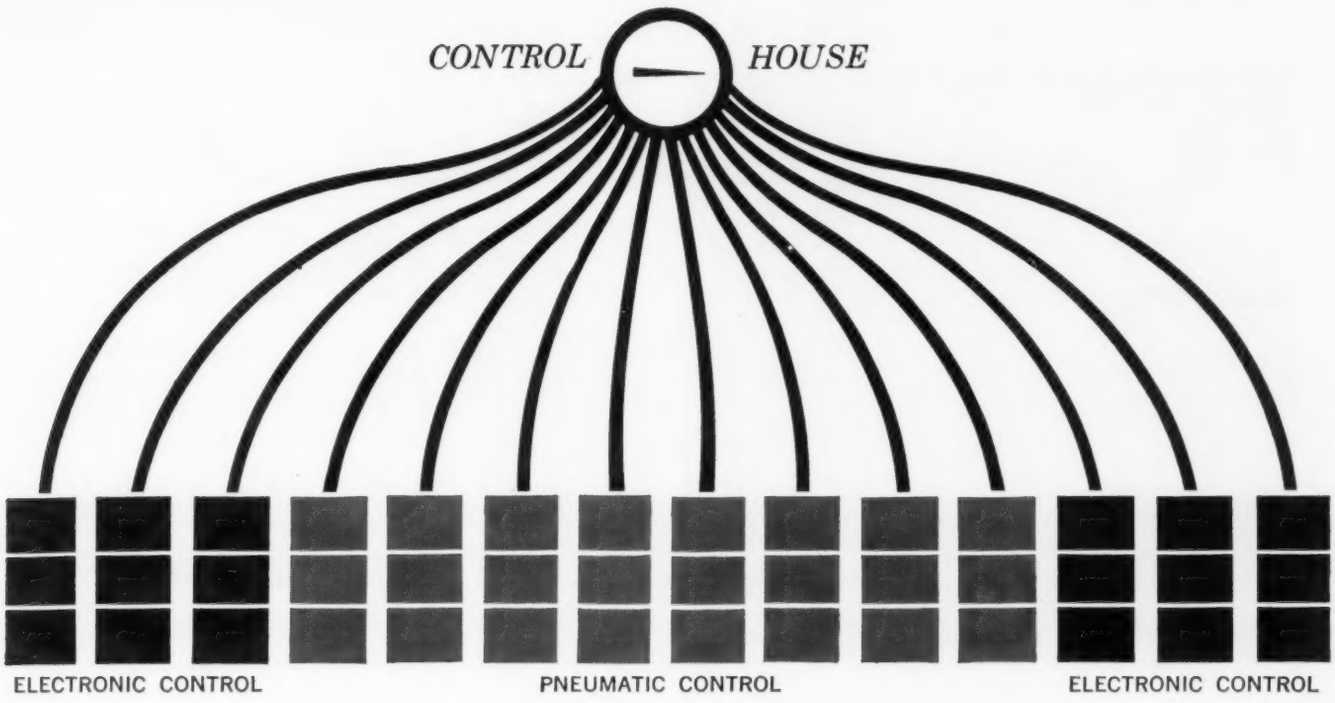
The price of the new product, about half the thickness of tin-

Don't take chances on couplings

CHECK PUBLISHED MISALIGNMENT RATINGS BEFORE YOU BUY

Since misalignment is the basic problem that shaft couplings are designed to solve you'll find a published conservative misalignment rating (along with load capacity rating) for every Fast's Coupling. Compare it with the misalignment rating of any other coupling you are considering.
One further advantage of Fast's Couplings' misalignment ratings: You save money on installation because, knowing the ratings, you don't have to line up driving and driven elements with pinpoint accuracy. It's one more important reason why Fast's Couplings are the choice of more equipment manufacturers than any other gear-type coupling.
KOPPERS COMPANY, INC., 110 Scott Street, Baltimore 3, Md.

KOPPERS
FAST'S COUPLINGS
Engineered Products Sold with Service

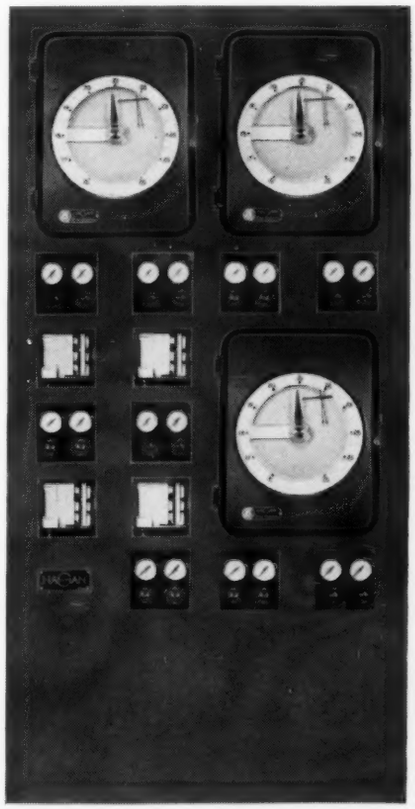


Centralized control puts panels for 42 SOAKING PITS in a single 50-FOOT CONTROL HOUSE

A major steel producer engaged in an expansion program projected the building of 42 new soaking pits, arranged in 14 rows of 3 pits each, *but the space available for a centralized control house was only 50 feet long.* In addition, each panel must provide high visibility of pit temperatures, heaters wanted to be able to see the entire trend of the heat on recorder charts, metallurgists wanted daily access to individual pit temperature and fuel flow records, the instrument department wanted chart changing held to a minimum.

Two recent Hagan developments provided the solution to this problem—one was a new instrument which records both pit temperature and fuel input on a single 24-hour chart, and has a highly readable pit temperature indicator. The other was the use of Hagan PowrMag electronic (magnetic amplifier) control for the 6 rows of pits furthest from the central control house. Row variables—flue pressure, air pressure, combustion air pressure and recuperator temperature—are recorded on standard 30-day miniature strip chart instruments.

With this arrangement, all of the user's requirements were met. Here



Complete control for one 3-hole row of soaking pits is housed in this 3½-foot panel.

are the details on how it works out:

1. Panel width is exactly 3½ feet per 3-hole row, so the panels for all 42 pits total 49 feet. This permits the use of the desired centralized control house, attended by one heater.
2. Only one chart per pit will be changed daily. This can be done when the instrument man date stamps the 30-day charts.
3. The entire record of a heat is visible on the 24-hour chart without need for withdrawing the instrument from its case.
4. The indicating scale showing pit temperature has high visibility—the heater will have no difficulty keeping track of each row.

Hagan electronic and pneumatic controls are designed with the need for centralized control in mind. For assistance with your particular problem, write or phone for a Hagan engineer. For specific information on soaking pit controls, **ask for Bulletin MSA-177.**

HAGAN

CHEMICALS & CONTROLS, INC.

HAGAN CENTER, PITTSBURGH 30, PA.

HAGAN DIVISIONS: CALGON CO.—HALL LABORATORIES—BRUNER CORP.

NEW L&N TOP-GAS ANALYZER

for "top" efficiency in blast furnaces

The new L&N Top-Gas Analyzer enables the blast furnace operator to "see" percentages of critical furnace gases *seconds after the proportions actually exist in the furnace* . . . gives him important data for regulating wind rate, blast temperature, burden composition and distribution, moisture, etc. . . . helps him in controlling the chemical content of his melt *hours before the furnace is tapped.*

This L&N Analyzer is a rugged, completely "packaged" gas analysis system, so easily maintained it operates virtually unattended for days — even weeks at a time — with accuracy and high speed of response.

Fast response — Only 45 seconds, from change occurring in furnace to recording on chart . . . assures prompt knowledge of furnace conditions.

Strip-chart record — Percentages of each gas are recorded in 3 contrasting colors on a single Speedomax® strip chart . . . easy to read, easy to interpret.

Minimum maintenance — Measuring cells have no moving parts . . . use no chemicals, no combustion . . . require no replacement of sensitizing elements.

All cells in one cabinet — Saves space . . . cuts instrument costs . . . eliminates unnecessary piping.

Completely self-contained package — All sampling, analyzing, and recording equipment mounted on a single 24″ x 72″ panel.

Easily installed — 120 volt a-c power line, air-purge line, and standard copper-tubing sample-line are the only external connections required.

SEND FOR DETAILS — Your local L&N field engineer can give you complete information concerning a top-gas system to meet your requirements. For descriptive literature, call your nearby L&N office or write 4942 Stenton Avenue, Philadelphia 44, Pa.

LEEDS NORTHRUP
Instruments Automatic Controls • Furnaces

Pioneers in Precision

plate now used in can making, ranges from $6.10 to $6.65 per base box at U. S. Steel mills at Pittsburgh and Fairless, Pa., Gary, Ind., and Fairfield, Ala.

" 'Ferrolite' has proved to be the economically sound product we thought it would be," Mr. Worthington said. "It combines the qualities of proportionally greater strength and lighter weight with lower material cost.

"Substantial quantities of six-ounce cans made of this lighter tinplate have been used successfully in packaging frozen concentrates. Similarly, success has been realized in packaging motor oil in quart cans," Mr. Worthington noted.

INSTALL MICROANALYZER AT J&L RESEARCH LAB

△ Metallurgists at Jones & Laughlin Steel Corp. now have a tool which will permit exploration of areas in steel and steel products so small that it would take 250 of them to span the thickness of a razor blade.

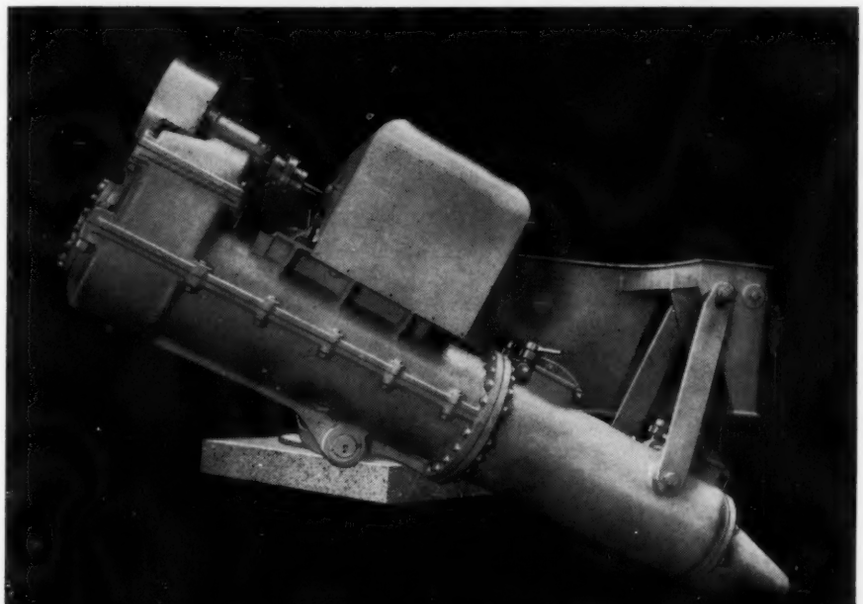
The new instrument—an electron probe microanalyzer—is a recent development for detailed studies of minute regions which could hold the key to new and better steels, according to Dr. H. S. Turner, J&L's vice president—research and development. It has been installed at the company's Graham Laboratory.

"There is little doubt that the electron probe microanalyzer represents a very important technological break-through in chemical analysis of steels," Dr. Turner said. "It makes possible the combined study of microstructure and chemical composition for the development of new products as well as for increased quality control.

"The new technique is far more selective than even the best microchemical method since it does not alter the sample or its surrounding structure. For the first time the steel metallurgist can determine the exact composition of a minute segment of steel *in situ* (in its natural or original place) and can detect the changes in chemical composition from one microscopic grain to another which have occurred during solidification, in subsequent processing, and in heat treating.

"This study is important since the small regions in steel rather than

IN CLAY GUN PERFORMANCE...



THE LEADER BY FAR IS BAILEY

Extremely accurate and fast positioning, Bailey Clay Guns furnish the high clay pressures (642 to 1150 psi) which are so necessary with the new coke-tar tapping hole mixes now being used on many furnaces. Unique mounting and 3-motor operating system assure quick and reliable positioning in the tapping hole. There are more than 170 Bailey Clay Guns in blast and electric furnace service.

• *Write for bulletin.*

WILLIAM M. Bailey COMPANY
ENGINEERS
LEADERSHIP THROUGH QUALITY
1221 BANKSVILLE ROAD PITTSBURGH 16, PA.

Another good customer is assured

PREDICTABLE PERFORMANCE

with a SECO

60" SLITTING LINE

This "custom-built" SECO 60" Slitting Line, recently installed in a midwestern steel company's plant, was designed and built to their exact specifications to provide maximum performance.

Features of this custom-built SECO Slitting Line are:

- Coil weight capacity—40,000 lbs
- 225 fpm line speed with build-up to 735 fpm
- .1875 max. material thickness—5 cuts
- .020 min. material thickness—20 to 30 cuts
- Line arranged to handle sheets or coils
- Power driven hold-down rolls for uncoiling heavy gauge material
- Peeler and Straightener at uncoiler minimizes manual handling
- Variable speed D.C. drive
- Control equipment at operator's desk
- Over-arm separator at recoiler
- Removable housing assembly for quick knife changeover away from slitter

Whatever your requirements, SECO can provide a complete range of Slitting Lines—from 12" to maximum strip widths—as well as other Steel Mill equipment. SECO's staff of trained sales engineers are at your service to assist you with any production problem you may have. Call or write today.

SECO

SECO STEEL MILL EQUIPMENT

- Leveling and Shearing Lines
- Combination Edging and Flattening Lines
- Tension Reels for Strip Polishers
- Narrow Strip Grinding Machines
- Slitting Lines
- Multiple Strand Pull-out Rolls and Take-up Frames
- Strip Coilers (Up and Down Type)
- Traverse Reels for Narrow Strip
- Steel Coil Up-enders
- Scrap Ballers

Affiliated with Lee Wilson Engineering Co., Inc.

STEEL EQUIPMENT COMPANY

P. O. BOX 737, WARRENSVILLE STATION
CLEVELAND 22, OHIO

the average composition usually dictate the important deviations from standard material behavior."

The principle involved in electron probe microanalysis is that the high energy electron beam of the equipment excites x-ray emission from atoms within the region under examination. Each element gives off an identifying x-radiation. By means of crystal analyzers and Geiger counters, the radiation can be measured and amounts of individual elements determined.

It is possible to perform a quantitative analysis on an area so small that it is scarcely visible in a microscope.

"The amount of steel required as a sample for the actual analysis is unbelievably small—in the range of one-millionth of one-billionth of an ounce," Dr. Turner said. "The sample must be, of course, contained in a larger mass but there is no difficulty in carrying out a whole series of analytical tests on the broken end of a sewing needle."

FIRM ANNOUNCES NAMING OF BRITISH LICENSEE

△ Pennsylvania Engineering Corp. has signed a license agreement which allows a British firm to sell and build PECor L-D oxygen furnaces and auxiliaries in the United Kingdom, Europe, Australia and South Africa.

Ashmore, Benson, Pease & Co. Ltd., a member of the Davy-Ashmore Group, is the licensee. Terms of the agreement provide that Pennsylvania Engineering will furnish technical data, engineering, drawings and specifications required to allow Ashmore, Benson, Pease to make proposals and to build the equipment when orders are received.

In addition to basic oxygen converters, the agreement includes PECor-designed post cranes, mixers, scrap charging cars, smoke hoods, slag and blown metal transfer cars.

APPOINTS BELGIAN FIRM FOR REFRACTORY SALES

△ The Ramtite Co. of Chicago has signed an agreement with S. A. Pises Speciaux et Monoblocs Plastiques of Belgium covering the sale and distribution of Ramtite refractory products to the steel and

DRAVO DISCS
offer these plus values for pelletizing and mixing . . .

- Pellet uniformity is far superior to that produced by other methods.
- Continuous operation (not batch) assures higher production rates.
- Binder is unnecessary in many cases.
- Low overall cost per ton of output.
- Material in process can be viewed continuously.

Send for Bulletin Number 247. Write Dravo Corporation, Pittsburgh 25, Pennsylvania.

Manufactured under license agreement with Lurgi of Frankfort, Germany.

DRAVO
CORPORATION

MANY FAST'S HAVE BEEN WORKING LONGER THAN YOU

It's a fact. There are plenty of cases where Fast's Couplings have been in service 20 to 40 years. And some of our more enthusiastic engineers say a Fast's should last forever if it's properly applied, installed and lubricated. Whatever opinion you accept, you can bet Fast's Couplings will give you the same smooth-running, low-maintenance, long-lived performance that makes them the choice of more equipment manufacturers than any other gear-type coupling.

For example, Fast's Coupling No. 1347, shipped in July, 1922, is still in service—and the customer is just ordering his first spare coupling 38 years later.

KOPPERS COMPANY, INC., 110 Scott Street, Baltimore 3, Md.

KOPPERS
FAST'S COUPLINGS
Engineered Products Sold with Service

allied industries in Belgium, Luxembourg, France, England, Italy and Spain.

Pises Speciaux will service Belgium and Luxembourg from their present office and warehouse stocks will be established in France, England, Italy and Spain to provide technical assistance and availability of materials to customers in those countries.

The agreement also provides for assistance on engineered applications and other technical matters, and a license arrangement for the manufacture of certain Ramtite refractory products in Europe.

J&L ORDERS ELECTRONIC SCALE CAR FROM ATLAS

△ A new scale car with all electronic weighing has been ordered by Jones & Laughlin Steel Corp. from The Atlas Car & Manufacturing Co. To be installed at J & L's Pittsburgh Works, it is believed to be the first new scale car with electronic scales ordered for blast furnace stockhouse service.

The 24 in. indicating and recording scale dial in essence is the same as has been used on Atlas scale cars for many years, thus simplifying the supply of spare parts.

The scale dial and printing mechanism are identical, with the exception that the Servo motor of the electronic scales is substituted for the usual parts used with the mechanical scales.

MACHINE SHOP EXPANDED AT HYDE PARK PLANT

△ Work will soon be completed on Hyde Park Foundry & Machine Co.'s expansion and modernization of their machine shop facilities. A new heavy machine shop building with 27,000 sq feet is being built to augment erection and heavy tool facilities.

The main bay will have a 60 ft center aisle with capacity for 75 ton cranes. This additional space will enable the firm to build larger equipment for the ferrous and nonferrous industries.

When work is completed this fall, the production facilities at Hyde Park will occupy about 150,000 sq ft.

APPOINTED AGENT FOR FRENCH SHEAR COMPANY

△ The Metal Processing Machine Co., a division of the McKay Machine Co., has been appointed exclusive sales representative and manufacturer in the United States for the Corpet Louvet Hydraulic square and bevel shear.

The new shear was developed in France by Corpet Louvet et Cie., and is designed to square shear and bevel shear steel or nonferrous plate in one operation. Present designs will process plate up to 1¼ in. in thickness.

Meetings

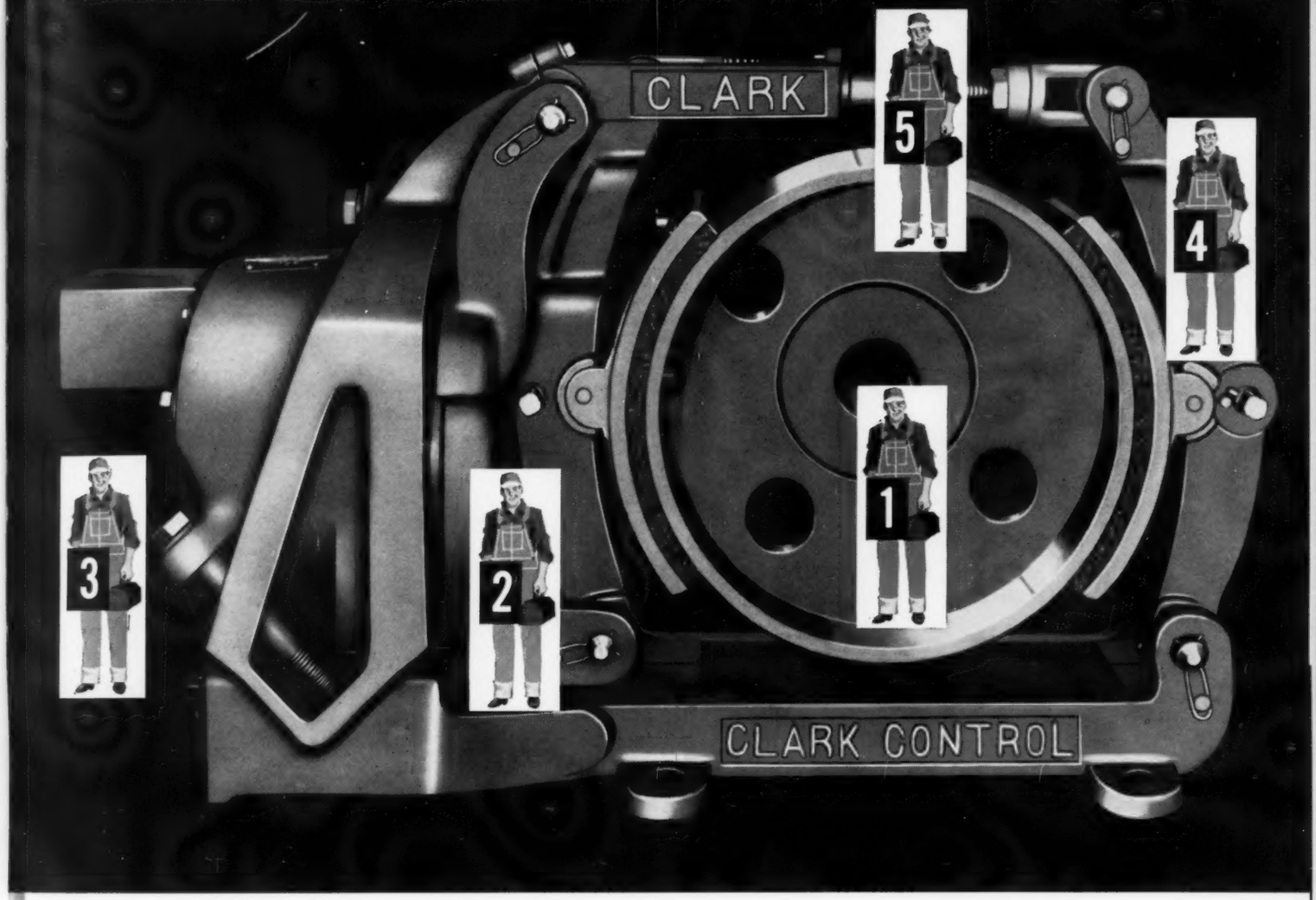
△ The 42nd meeting of The Galvanizers Committee of the steel industry, sponsored by the American Zinc Institute, Inc., will be held at the Onesto Hotel, Canton, Ohio, on October 27–28, 1960.

△ The annual convention of the Wire Association will be held November 14–17, at the La Salle Hotel, Chicago, Ill.

SUPERIOR
CARBON
BRICK
FOR
◀ Blast furnace linings
◀ Blast furnace run-out troughs
◀ Cupola linings
◀ Steel pickling tanks
Standard sizes and shapes • Tested performances
Competent technical service • Superior chemical and metallurgical characteristics • Graphite brick also available.
May we give you a quotation?
ELECTRODE GLC DIVISION
GREAT LAKES CARBON CORPORATION
18 EAST 48TH STREET, NEW YORK 17, N.Y. • OFFICES IN PRINCIPAL CITIES

LOOKING FOR

SIMPLIFIED MAINTENANCE?



Here's how Clark design helps

Any brake works properly when new. Clark brakes are easy to keep working that way.

It's the brake troubles that occur *after* thousands of operations that Clark engineers had in mind when they designed the AISE-NEMA D-C Magnetic Brake line.

Hundreds of successful applications attest to the design superiority that has made these brakes the choice of maintenance men wherever service conditions are most rugged.

Clark maintenance-reducing features include:

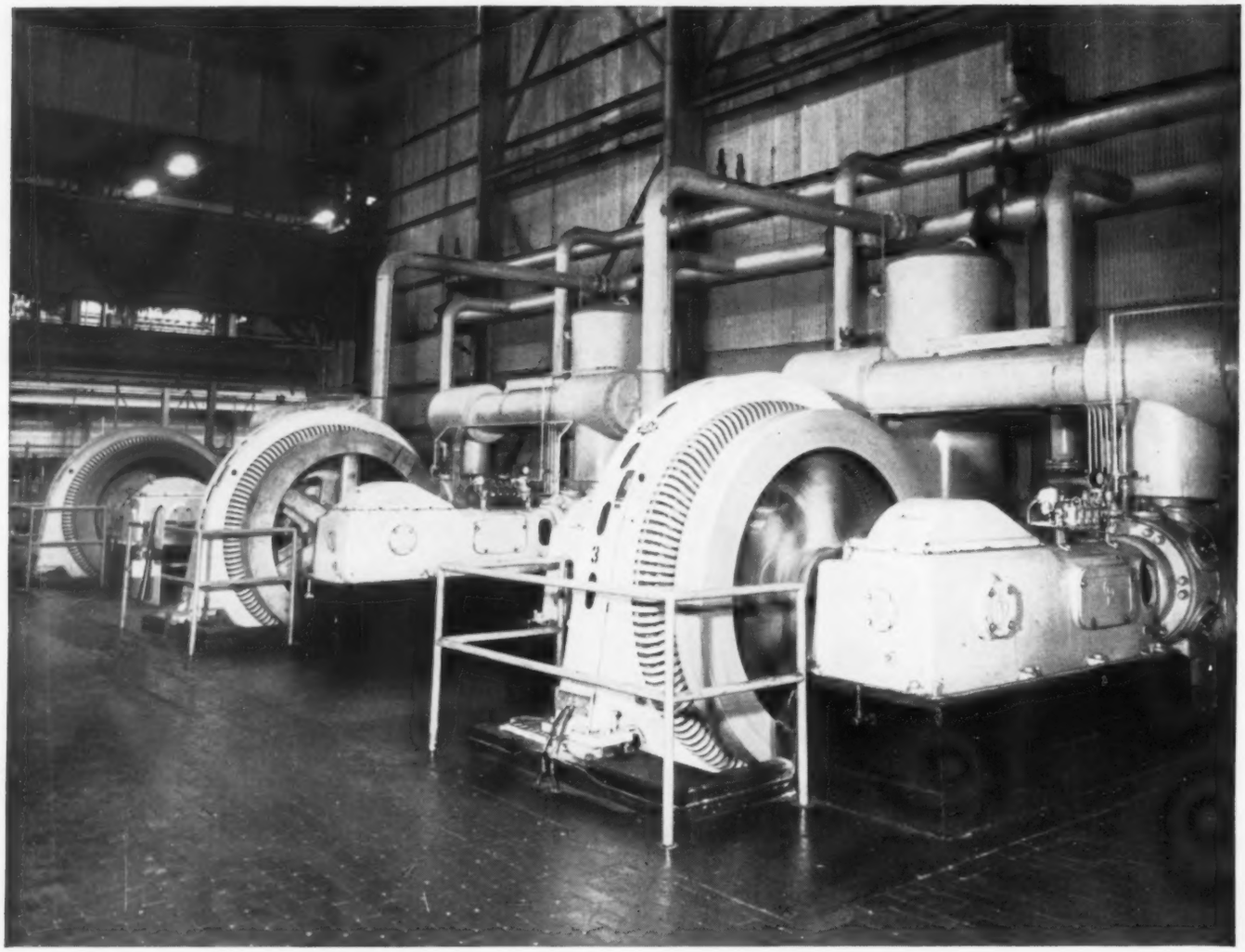
1. Powerful "nut-cracker" principle of operation, with shoe-arms hinged at top, assures equalized pressure on both shoes, improves lining life.
2. Top-hinging of magnet armature puts widest part of magnet air gap at bottom, so most of the dirt falls free—minimizing stoppages.
3. Magnet case and coil replaceable on the job without affecting brake adjustment or releasing brake. Self-contained, epoxy-potted coil is quickly and easily replaced in the case.
4. Interchangeable self-aligning shoes are readily replaceable and fit either side, either end up.
5. Maintenance adjustment is on *top* of brake for easy access.

PLUS many other Clark "maintenance-saver" features that greatly reduce downtime, speed maintenance, simplify adjustments and replacement of wearing parts.

For complete details on Clark D-C magnetic brakes, request a copy of Bulletin 106-B from your nearest Clark Controller sales office. Or write to: 60MB1

The
CLARK CONTROLLER
Company

Main Plant: *Cleveland 10* • **Western Plant:** *Los Angeles 58*
In Canada: *Canadian Controllers, Limited, Toronto*



Above are three 500 hp, 225 rpm, 2300 volt, 0.8 power factor E-M Synchronous Motors driving air compressors in the tin finishing department at the new Fairless Works of United States Steel Corporation. Three other 500 hp and five 300 hp E-M Motors also drive air compressors, in the hot strip and slab mill, central power station, open hearth pumphouse and sulfate building of the coke works.

Power costs held low on compressor drives at new Fairless Works

Supplying air for controls, tools, handling systems and maintenance equipment is vital business at Fairless Works. And cost of power for operation of the air compressors is an item to be watched in such a large mill.

That's exactly where the E-M Synchronous Motors fit in. They help contribute real economy and rugged reliability to compressor operation.

First of all, these 11 E-M Motors are capable of supplying approximately 2700 reactive kva to improve plant power factor, a significant element when you want to minimize power costs.

Secondly, the inherent high efficiency of E-M Synchronous Motors utilizes power most sparingly.

Other economies are accomplished by use of simple and low-cost full-voltage control for across-the-line starting. Maintenance economy is foretold by simplicity of E-M Synchronous Motor direct-connection . . . by extra strong lashing of E-M stator coils . . . by the high capacity of E-M cage windings to withstand repeated starting stresses.

To get top performance from your large compressor drives, discuss your needs with your nearest E-M sales engineer. And write factory for E-M Synchronizer No. 42, a special issue on the ABC'S of Synchronous Motors.

ELECTRIC MACHINERY MFG. COMPANY
MINNEAPOLIS 13, MINNESOTA

E-M

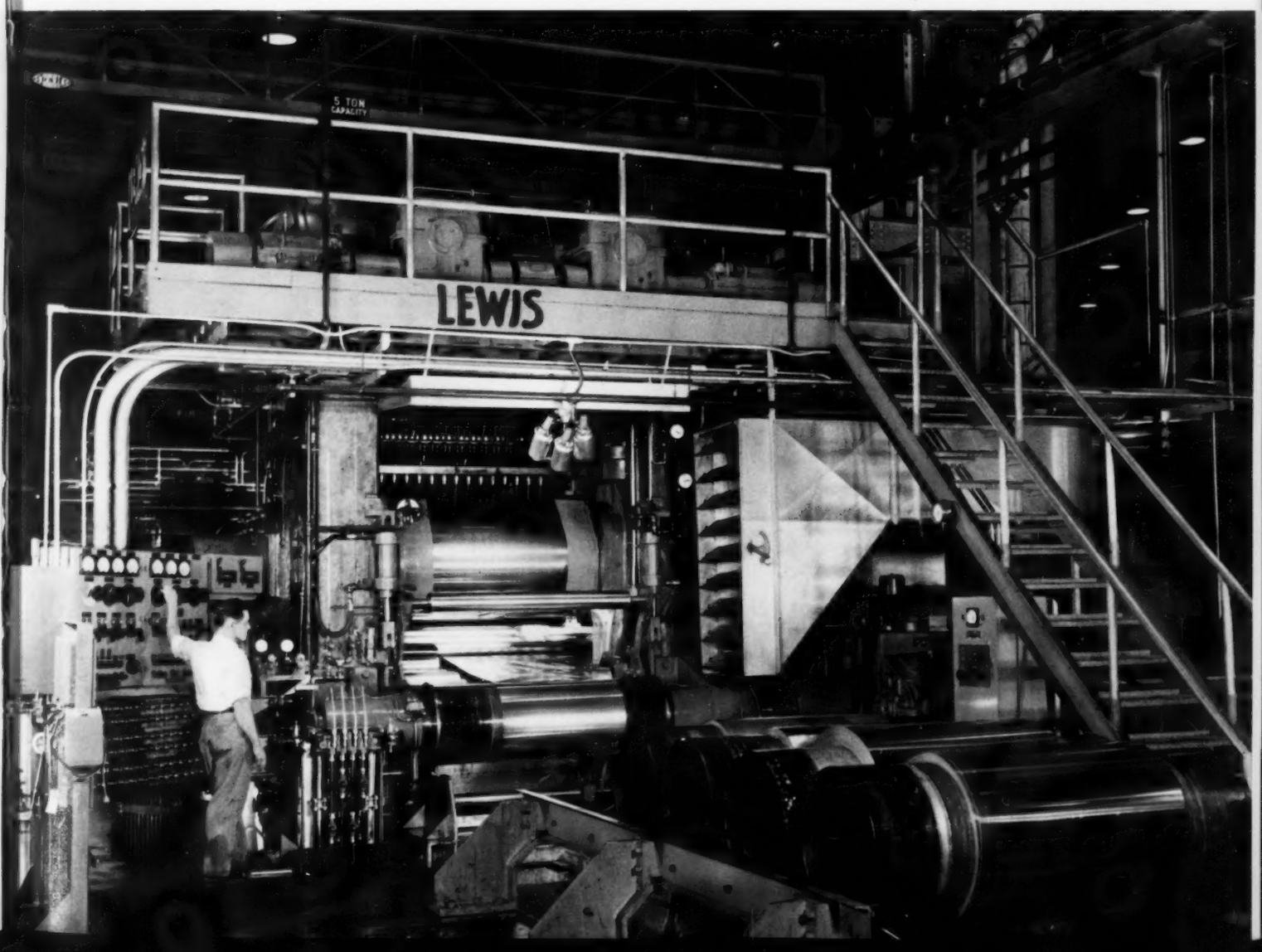
1200-TPA-2168A

Specialists in making motors do
EXACTLY WHAT YOU WANT THEM TO

BLAW-KNOX

Blaw-Knox designs and builds a full range of aluminum foil mills complete with auxiliary equipment to meet individual requirements. Other Blaw-Knox equipment for the metals industry includes complete rolling mill installations and auxiliary equipment for ferrous and non-ferrous metals, sheet and strip processing equipment, electrolytic tinning, annealing, and galvanizing lines, seamless pipe and tube mills, draw benches, and cold draw equipment, Blaw-Knox Medart cold finishing equipment, iron, alloy iron and steel rolls, carbon and alloy steel castings, fabricated steel plate or cast-weld design weldments, steel plant equipment, and heat and corrosion resisting alloy castings. Blaw-Knox Company, Foundry and Mill Machinery Division, Blaw-Knox Building, 300 Sixth Avenue, Pittsburgh 22, Pennsylvania.

9½ and 34-inch by 60-inch Foil Mill



GAS WASHERS FOR THE STEEL INDUSTRY

CHEMICO DOES THE COMPLETE JOB

Planning / Design / Engineering / Erection / Start-up

Chemico handles the installation of Venturi gas washers on a turnkey basis. There is just one contract, one fee, and one organization responsible for every step – from initial planning to final start-up. Chemico's more than 40 years of experience in erecting major process plants is your assurance of an efficient, economical construction job, with a trouble-free "on-time" start-up.

Thirty-six Chemico Venturi blast furnace washers are now in successful operation or on order for 20 separate steel plants. Other units are setting new gas cleaning performance standards on oxygen steel converters, open hearth furnaces and gray iron cupolas.

Contact Chemico if you are looking for top performance gas cleaning in your steel plant operation.

at right is a photo of a Chemico Venturi gas washer and cooling tower at work on a blast furnace.

CHEMICO

CHEMICAL CONSTRUCTION CORPORATION
Gas Scrubbers Division
525 West 43rd Street, New York 36, New York

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HOUSTON
PORTLAND, ORE.
TORONTO
LONDON
PARIS
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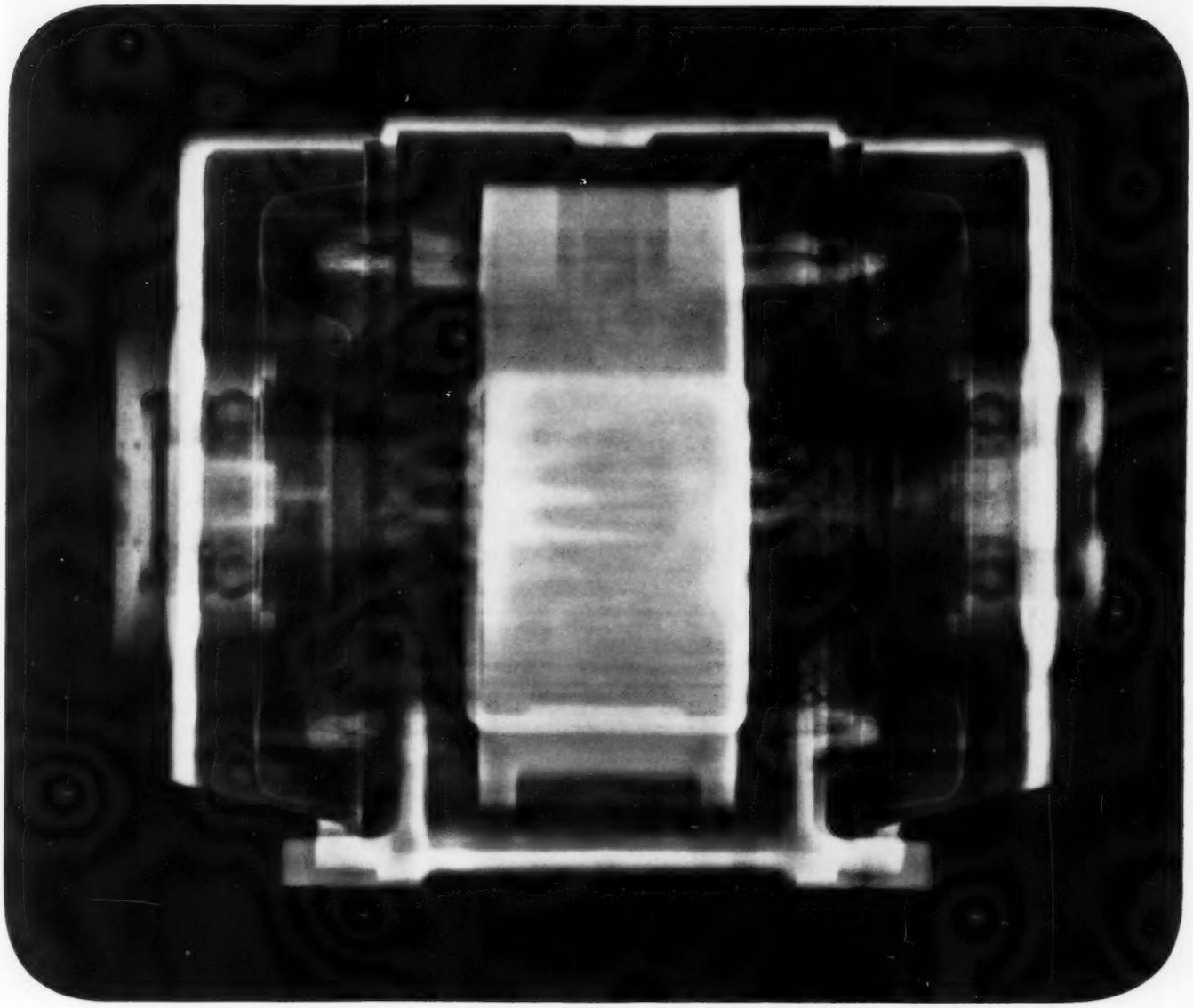
ALLIS-CHALMERS

A-1337



Actual radiograph of a 5-hp open-type motor taken with a 24-million volt Allis-Chalmers Betatron.

X-ray view of motor health

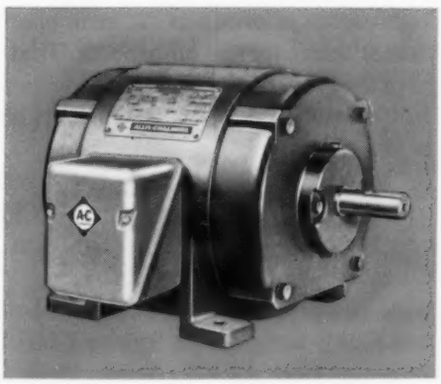
Invisible standards of perfection increase life expectancy of every Allis-Chalmers motor

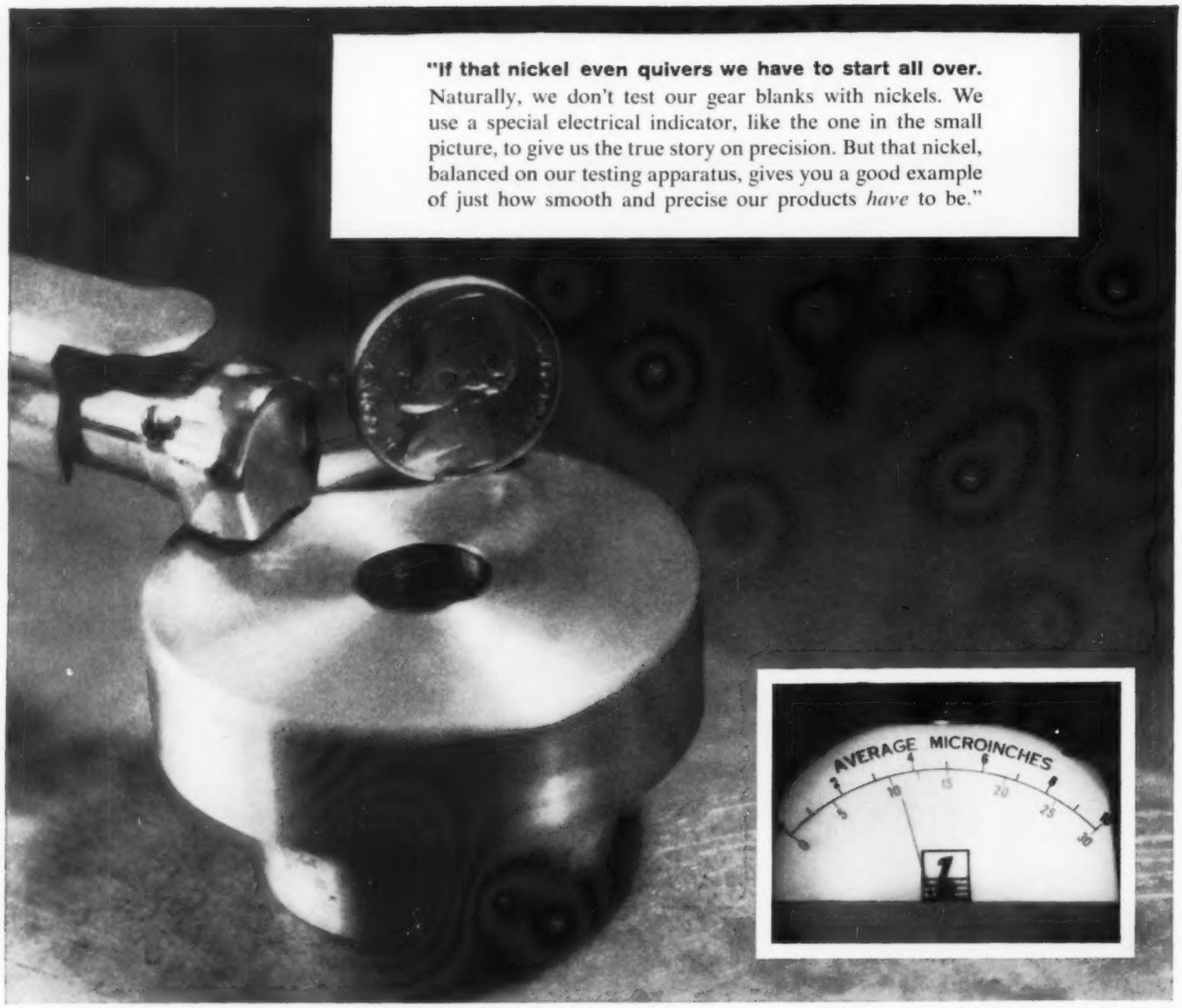
The exceptionally long performance of A-C open motors proves the value of thinking *beyond* established standards of design . . . of taking "significant new achievement" as the ideal.

This ideal led to many refinements for A-C open motors: double-shielded bearings that keep dirt out and allow controlled migration of grease, permanently numbered lead spacer and leads for easy identification and connection, and heavy-duty cast iron frames that resist corrosion and keep rotating parts perfectly aligned.

For totally-enclosed, open-type and *Super-Seal* general purpose motors, and electrically or mechanically modified definite-purpose motors, choose the motor built to invisible standards of perfection. Choose A-C. Special application help available.

Call your nearby A-C representative. Or write **Allis-Chalmers,** *Industrial Equipment Division, Milwaukee 1, Wis.* Super-Seal is an Allis-Chalmers trademark.




"If that nickel even quivers we have to start all over.
Naturally, we don't test our gear blanks with nickels. We use a special electrical indicator, like the one in the small picture, to give us the true story on precision. But that nickel, balanced on our testing apparatus, gives you a good example of just how smooth and precise our products *have* to be."
AVERAGE MICROINCHES
2
4
6
10
15
20
25
30
5
7

"We depend on Cities Service for absolute precision!"

Lester E. Hoffmann, Treasurer and Vice-President
American Screw Machine Products Co., Chicago, Ill.

"The screw machine business is a highly competitive trade. We've built our business and our reputation on top quality, high-precision products . . . gear blanks that require the closest tolerances in *all* aspects. That means *we have to have* the best-quality cutting oil available. We've depended on Cities Service for nearly 25 years and they've never let us down."

"Matter of fact," says Mr. Hoffmann, "they insisted we try other brands just to prove that Cities Service was the best for us. They proved their point. We've stuck with Cities Service."

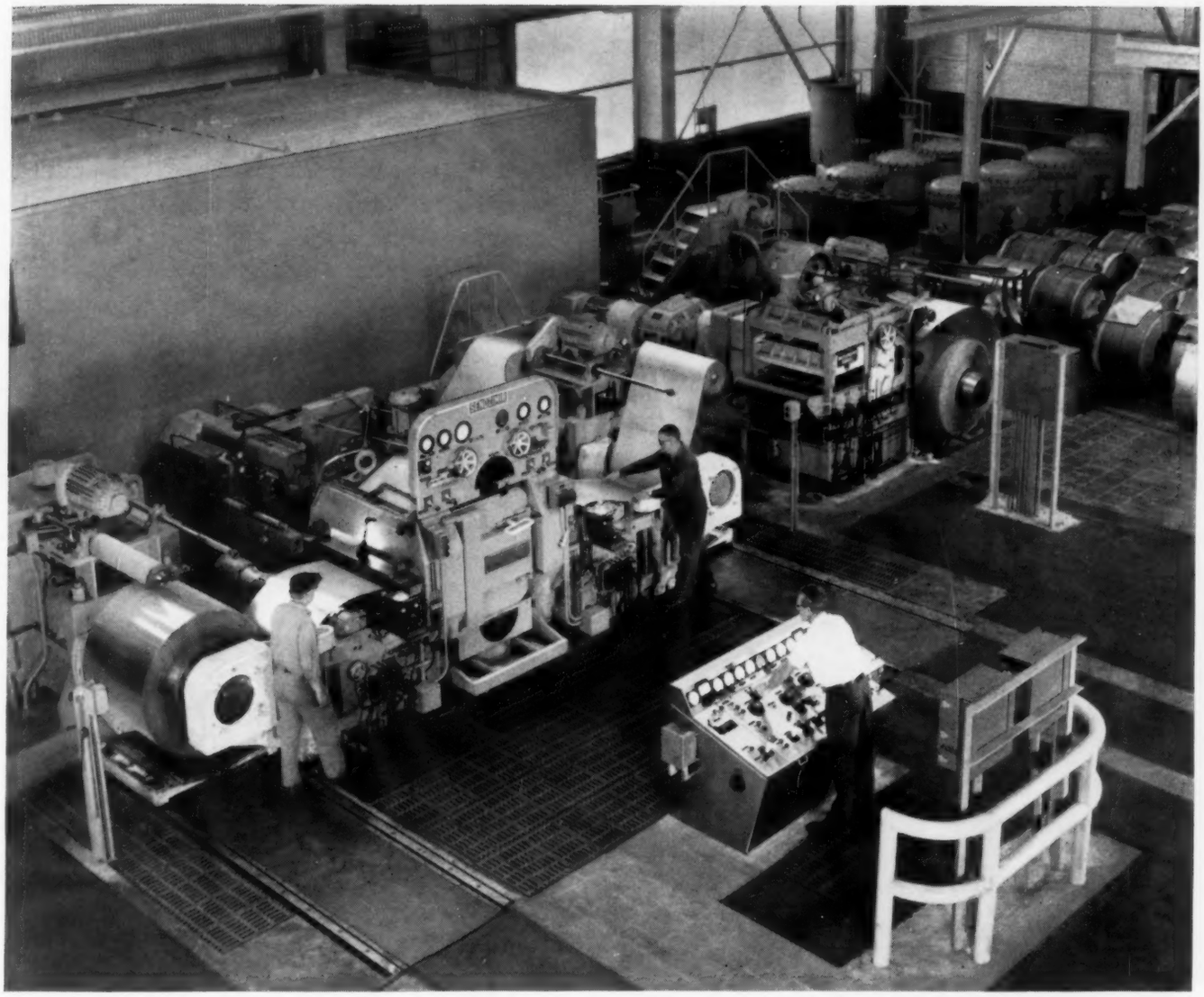
At the present time, American Screw Machine Products Co. is using Cities Service CHILLO 10 Cutting oil, and some CHILLO 22. As Mr. Hoffmann says, "The sulphur and chlorine additives prevent welding and galling action which allows for fine finishes and long tool life that maintains high-precision, top-quality work."

If you use petroleum products in your operations, why not talk with your Cities Service Lubrication Engineer? He can help you get the most from your operations by giving you the finest products, the best service available. Or if you prefer, write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

ALLIS-CHALMERS



High-luster stainless steel strip, as thin as .005-in., is produced on this 37-inch Sendzimir mill powered and controlled by Allis-Chalmers equipment.

Sendzimir mill control system provides

uniform gauge...uniform quality

Rolling uniform gauge, thinner than .005 inch, is made possible by Allis-Chalmers Sendzimir mill control systems. Speed, tension and roll separation are precisely coordinated to assure uniform thickness and quality throughout the coil.

Tachometer feedback provides precise speed regulation. A load cell senses strip tension to provide automatic tension regulation. Strip break protection is provided by a completely new, non-contact system developed by Allis-Chalmers. Magnetic amplifier switching circuits, in conjunction with an indicating tensiometer, stop the mill and sound an alarm quickly and reliably. This system can be applied on any mill with an indicating or regulating tensiometer.

Allis-Chalmers is now applying a complete control system to a 3,000 fpm non-reversing Sendzimir mill—the fastest and largest to be built in this country. In addition to control systems for finishing mills, A-C offers a wide range of data logging and control systems for all your rolling and processing operations.

For the complete story on how A-C control systems mean more profit for you, call your nearby A-C sales office. Or write **Allis-Chalmers,** *Industrial Equipment Division, Milwaukee 1, Wisconsin.* A-1378

EVERY TYPE—EVERY USE

SKF®

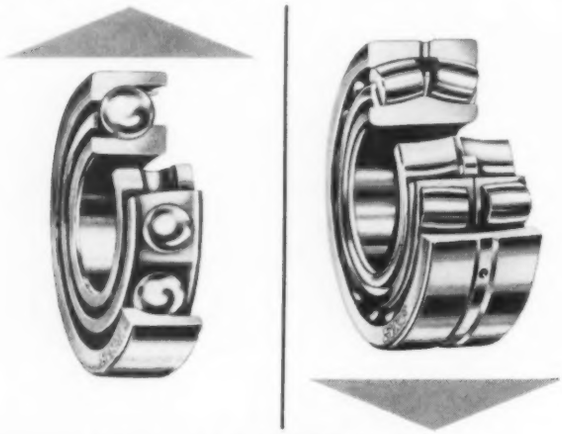
INDUSTRIES, INC., PHILADELPHIA 32, PA.

Spherical, Cylindrical, Ball, Tyson Tapered and REED Miniature Bearings

ANGULAR CONTACT BALL BEARING

This is the bearing to use when you need a high-speed bearing to support either (a) heavy thrust load, or (b) thrust load combined with radial load. It lends itself to various mounting arrangements. For example, if you need axial rigidity and high radial capacity you can mount two of these bearings in pairs either face-to-face or back-to-back. Or, if very high thrust capacity is needed, you can mount two or more of these bearings in tandem.

This standard bearing is available in over 80 sizes of single- and double-row types. Bore sizes range from ¾" to just over 7".



SPHERICAL ROLLER BEARING

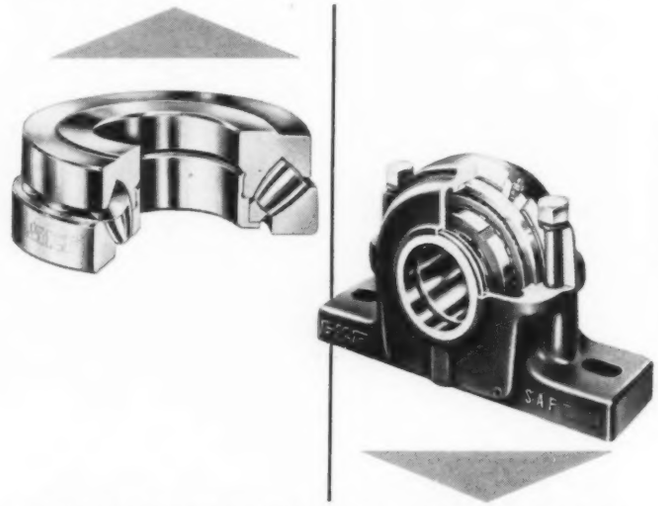
SKF invented the spherical roller bearing almost forty years ago. Since then, we've improved the original design several times—so that, today, our Type "C" spherical roller bearing offers longer life and 33⅓% greater capacity.

This increased capacity is largely due to the number, size and shape of the rollers—and the improved accuracy with which they're guided. Because these bearings are inherently self-aligning, their full capacity is always available for substantial thrust load in either direction as well as heavy radial load. These bearings also have special lubricating grooves that channel lubricants directly to the spherical rollers.

SPHERICAL ROLLER THRUST BEARING

Need a thrust bearing capable of carrying unusually heavy loads? Then specify this self-aligning spherical roller thrust bearing. It will carry either heavy thrust or combined thrust and radial loads. Because of its ability to carry high thrust at high speeds, this bearing is frequently chosen over large angular contact ball bearings for heavy-duty applications.

SKF makes this bearing in twenty-five standard sizes ranging from 4.3" to 14.9". And it's competitively priced.



TYPE SAF PILLOW BLOCK...with self-aligning ball or spherical roller bearings

Here's a rugged cast-iron pillow block that provides high efficiency with low friction.

We make this split pillow block with ball bearings for normal loads and with spherical roller bearings for heavy loads. We also equip it with Triple-Seal rotating rings that effectively protect the bearing from abrasives and corrosives, and prevent oil or grease from leaking out.

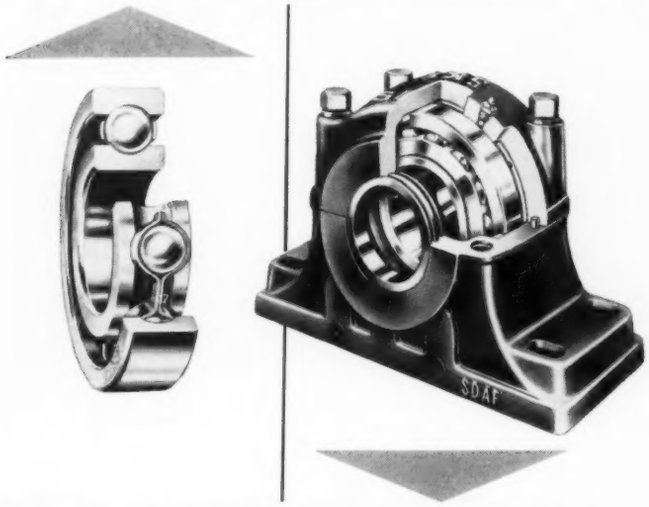
This pillow block can be mounted directly or with an adapter. Stabilizing rings are provided at no extra cost for applications where a "held" bearing is required to maintain shaft location. For heavy-duty applications, a cast steel housing (Type SAFS) is available. Shaft sizes from ¾" to 10½".

Only SKF can offer you unbiased bearing recommendations—because only SKF produces all four major types of anti-friction bearings: spherical, cylindrical, ball, and tapered roller bearings. For complete details on each type, just call the nearest of the twenty-four SKF sales offices.

SINGLE-ROW DEEP-GROOVE BALL BEARING

Here's a ball bearing that does two jobs, and does both of them well. It sustains heavy radial load as well as thrust load in either direction. Not only that, this bearing can be grease-lubricated when used at normal speeds and lubricated with oil at high speeds.

Yet this is a standard SKF bearing, mass-produced in various sizes at our automated Altoona (Pa.) plant. It's available in over 100 sizes ranging from over 5/8" O.D. to almost 16" O.D., and with various seal, shield and snap-ring combinations.



TYPE SDAF PILLOW BLOCK...with spherical roller bearings

Need an exceptionally sturdy pillow block? One that can withstand abnormal shock loads or heavy thrust loads day after day? Then specify SKF Type SDAF.

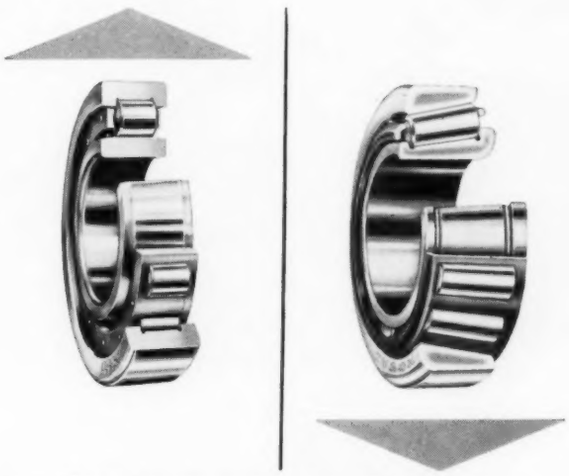
To provide maximum strength, four heavy bolts secure the cap of this pillow block to the base. Both halves are accurately aligned by dowel pins. And like the Type SAF, this pillow block comes equipped with Triple-Seal rotating rings that protect the bearing from foreign matter and retain the lubricant.

Type SDAF pillow blocks are made of cast iron but are also available in cast steel (specify Type SDAFS). They can also be mounted directly or with an adapter. Shaft sizes range from 2-11/16" to 14".

CYLINDRICAL ROLLER BEARING

Got a space problem? Here's a bearing that gives you high radial capacity—at very high speeds—in relatively small space. It's the SKF cylindrical roller bearing—which provides high radial capacity and minimum shaft friction. Controlled shaft end float within this bearing is a natural advantage of its design.

You can get prompt delivery in 154 bore sizes ranging from just under 1" to 6". Double-row cylindrical roller bearings are also available in bore sizes from 1" to 9.5".



Tyson® TAPERED ROLLER BEARINGS

What type of tapered roller bearing do you need: single-, double- or four-row? SKF's division, Tyson Bearing Company, makes all three of these types in a wide range of standard sizes.

The single-row type is especially suitable for carrying radial loads simultaneously. Double-row types are designed for use where the radial capacity of two single-row bearings is required. For special applications, the four-row type offers very high radial capacity in limited space.

All Tyson tapered roller bearings are interchangeable, size for size, with other makes of tapered roller bearings where the part numbers are the same.

5949

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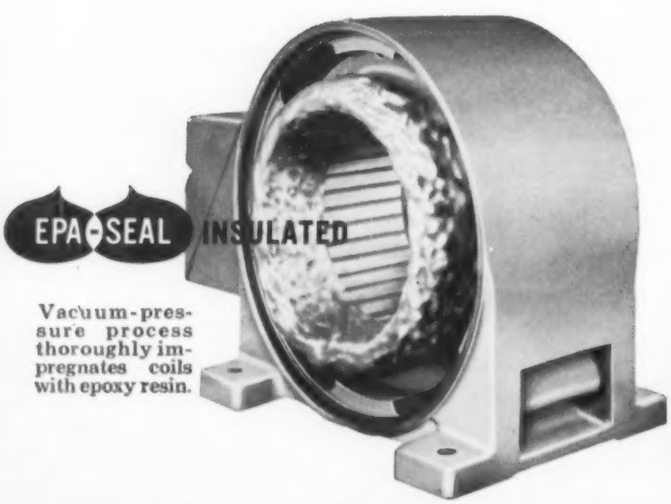
A complete line of integral HP motors: dripproof protected—totally enclosed—and explosion proof

ELLIOTT C-W MOTORS

conservatively designed, ruggedly built, highest quality throughout

The extra service users enjoy from Elliott C-W motors is due to the conservative design, precision manufacture and high-quality materials of these machines. For most applications, the dripproof-protected type gives dependable service. Where conditions are more severe the totally-enclosed or explosion-proof construction may be required. Recently added to the line are the EPA-SEAL epoxy insulated C-W motors for service where moisture or corrosive atmospheres demand superior insulation.



Vacuum-pressure process thoroughly impregnates coils with epoxy resin.

ELLIOTT Company
Crocker-Wheeler Plant
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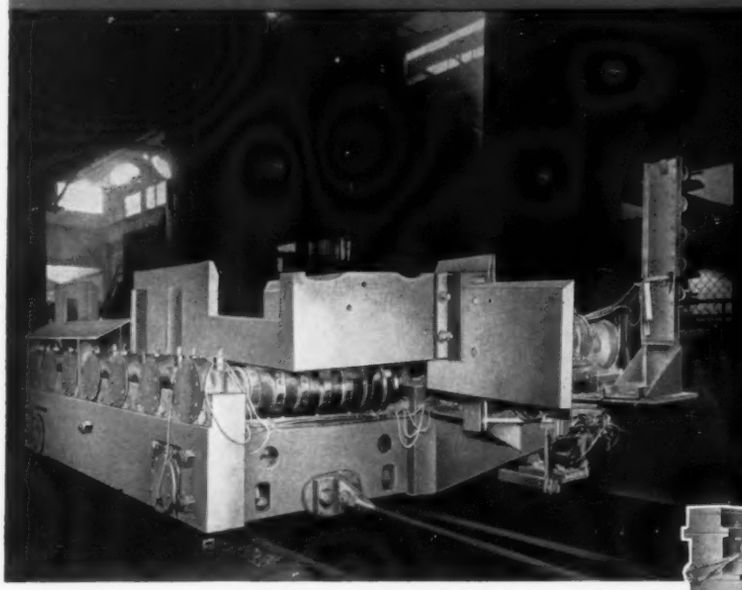
WO-2

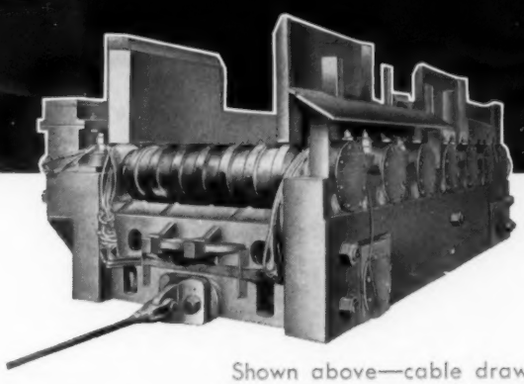
TREADWELL

cable-drawn table-top INGOT CARS

handling two 15-ton ingots... at a speed of 800 ft. *per minute*



Treadwell engineering was called on to develop the speed and efficiency needed for handling heavy ingots at high rates of speed. This ingot car has table rollers that are carried by anti-friction bearings and the axles are anti-friction bearing mounted. Write to Treadwell for any information on ingot cars.



- The table rollers are driven by Cleveland worm and gear sets and a Farval system for lubricating all bearings is built into the car.

Shown above—cable drawn table top ingot car at work in a major steel plant.

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Buss LOW-PEAK Fuses are designed to meet modern demands for electrical protection.

They safely interrupt fault currents up to 200,000 amperes . . . limit let-thru current to exceptionally low values . . . and hold 500% load for minimum of ten seconds.

Protect Mains, Feeders, Branch Circuits, Motors, Controllers, Switches—no matter whether the fault current is 1,000 amperes, 25,000, 100,000—or as high as 200,000 amperes.

Reduce stresses and prevent damage to Panelboards, Switches, Motor Controllers—other circuit components—because let-thru fault currents are limited to exceptionally low values.

Can be easily co-ordinated into a selective system—to limit fault outages to circuit of origin.

Prevent work stoppages, lights out, waste of time and money—because long time-lag keeps them from opening needlessly on motor starting currents or other harmless overloads.

Permit increasing interrupting capacity and current limitation on present electrical system at minimum cost. Buss LOW-PEAK Fuses fit standard switches and panelboards. Available from 15 to 600 amperes in both 250 and 600 volt ranges.

Guard motors against burnout from single phasing and overloads.

Low operating temperature reduces heating in switches and panels.

Provide thermal protection for equipment against damage due to poor contact.

Protect against waste of space and money by permitting the use of proper size switches and panels.

Remain safe throughout the years without maintenance or recalibration.

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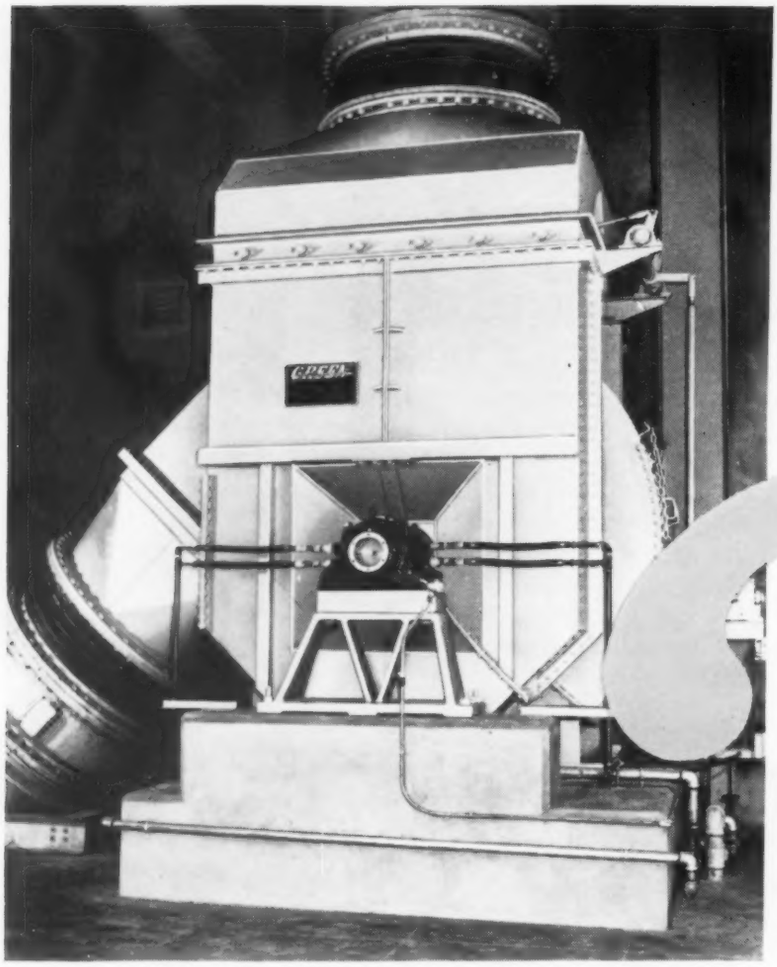


One of Brookhaven's three Green induced draft fans. Each exhausts 109,000 CFM at 56" S.P. and 140° F., operating at 1775 RPM. Each rotor was successfully subjected to spin tests producing 50% greater than normal operating stress.

WHY DID BROOKHAVEN SWITCH TO GREEN HIGH PRESSURE FANS FOR ATOMIC PILE COOLING?

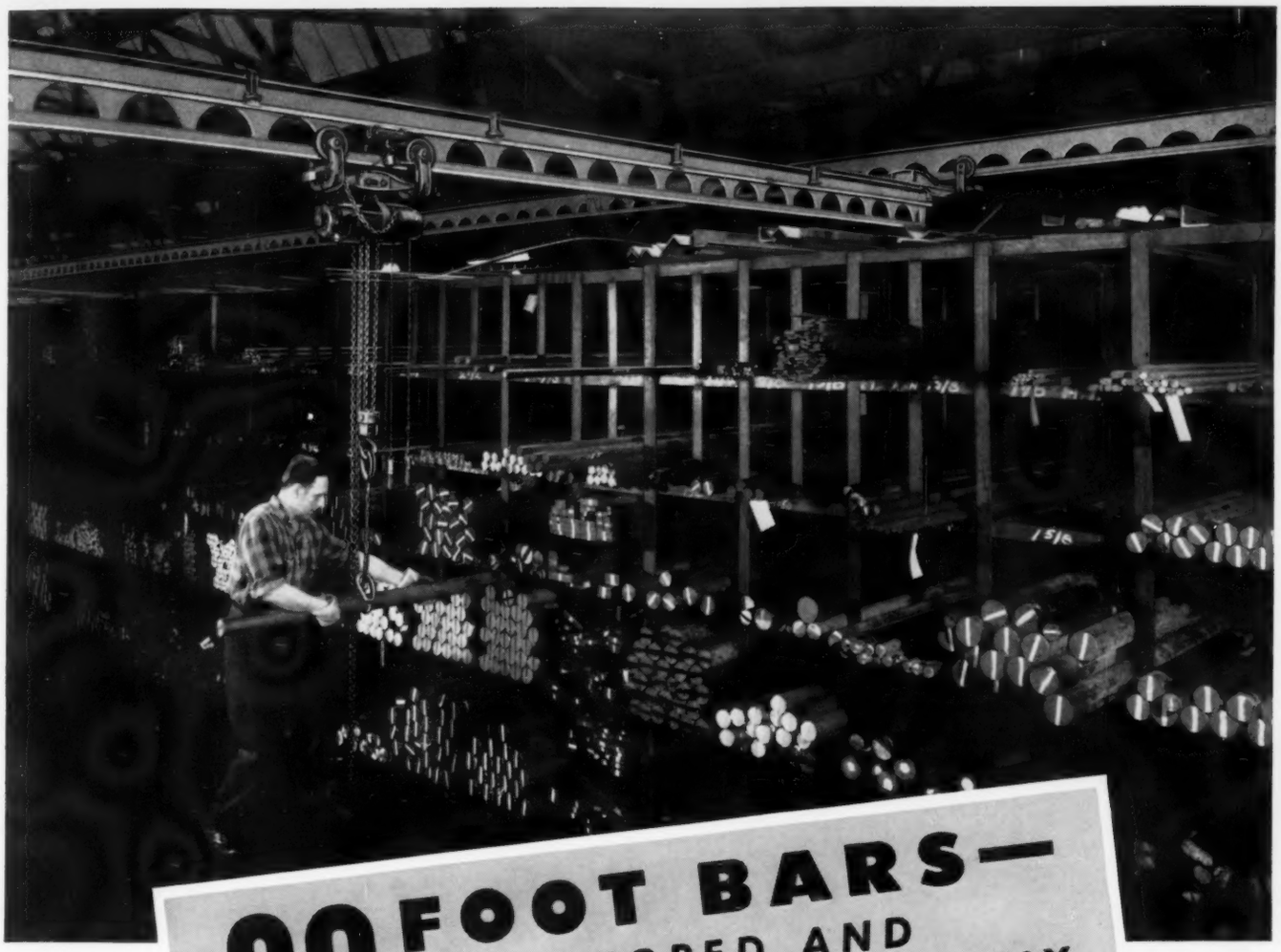
For 10 years, Brookhaven National Laboratory at Upton, N. Y. had used five fans of a leading make for exhausting the hot, slightly radioactive gases from its experimental atomic pile installation. These fans were still good, yet Brookhaven replaced them with three new Green units. Here's why:

Due to design changes in the atomic fuel, the air flow requirements changed considerably thereby making it economical to purchase new fans. This change in air flow requirements plus the new Green fans with their forged and machined rotors and efficient airfoil design (smoother air flow, less turbulence, less shock or eddy loss) save a total of $15/hour in power consumption. Not only does the replacement installation pay for itself, it gives Brookhaven brand new equipment, the most modern of its kind, built to provide the reliability their atomic application absolutely demands.

It will pay you—as it did Brookhaven—to investigate the replacement of your present fan equipment with new high efficiency Green airfoil fans.

Green

THE GREEN FUEL ECONOMIZER CO., INC. BEACON 3, NEW YORK



20 FOOT BARS— STORED AND HANDLED EFFICIENTLY

It is not only faster and easier to store and handle stock this way, but safety is greatly improved.

WITH a simple rack arrangement and overhead tramrail crane to serve it, long unwieldy steel stock can be stored in an orderly fashion and grouped according to shape, size and alloy.

The smooth rolling crane with hand-propelled or electric hoist makes it easy for a man to handle the bars in and out of the rack and deliver them to the saws or machine tools directly without rehandling.

What a vast improvement this is over the haphazard time-consuming way of storing and handling stock still prevalent in so many plants today. There is no tugging, lugging and back-breaking lifting while searching for stock needed. The stock is always in its place where it is quickly found. There is no uncertainty as to the amount on hand, because the supply is out in the open where it can always be seen.

Hundreds of metal-working plants and steel warehouses are now enjoying the many advantages that Cleveland Tramrail equipment provides. There are installations of every type from simple hand-propelled carriers and cranes to complete automatic systems that transport materials without need of accompanying operator.

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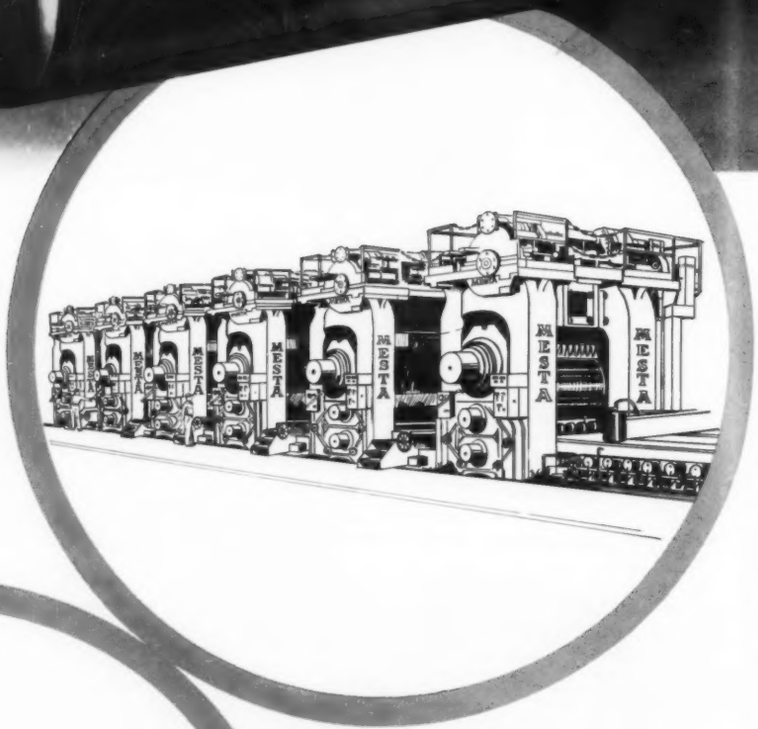
OVERHEAD MATERIALS HANDLING EQUIPMENT

MESTA ROLLS



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Personnel News...

Thomas A. Cleary, Jr., was named assistant superintendent of flat rolled and tubular products, The Youngstown Sheet and Tube Co. Formerly assistant superintendent of the Open Hearth Department at the Brier Hill plant, he succeeds **Jack E. Major,** who recently was appointed assistant general superintendent of the steel plant and Struthers Works. Mr. Cleary joined the company in 1943 as a laborer. He became a practice trainee in the Open Hearth Department, advancing through the ranks to his supervisory position.

Howard O. Beaver has been appointed assistant general superintendent of The Carpenter Steel Co. plant in Reading, Pa. Manager of mill metallurgy at the plant for the past two years, he came to Carpenter in 1948 and was named plant metallurgist in 1951 and production metallurgist in 1957.

Herbert L. Willke has been appointed director of engineering for The National Supply Co. His appointment followed the retirement of **Joseph R. Mahan** as director of research and engineering. Mr. Willke started with the company in 1930 as a field engineer at Houston, Texas. He was transferred to the Toledo, Ohio, plant in 1935 and was promoted to chief engineer there in 1946. He was transferred to the Pittsburgh general offices in 1956 as assistant director of engineering. At the same time, **Kenneth W. Dudley** was appointed chief engineer at the firm's Torrance, Calif., plant. He succeeds **Forrest J. Young,** who retired after 43 years of service at the plant. Mr. Dudley started with the company as a draftsman in 1941, and in 1948, he was appointed a design engineer. He has been a project engineer since 1949.

Edward S. Bunn, chief metallurgist of Revere Copper and Brass Inc., has been appointed general manager of the company's Research and Development Department. Mr. Bunn joined Revere in 1932 as a research metallurgist. From 1934 to 1943, he served as assistant director of research and from 1943 to 1953 he was metallurgical manager of Revere's former Aluminum Division in Baltimore. He was appointed chief metallurgist for Revere in 1953. Prior to joining Revere, he worked in the research departments of the General Electric Co. in Schenectady, N. Y., and the Bridgeport Brass Co. in Bridgeport, Conn.

Carl D. Ahlstrom was appointed district sales manager for General Electric Co.'s Power Tube Department in the New York metropolitan area. He joined General Electric in 1950, served as an application engineer in the company's Small A-C Motor and Generator Department, and later joined the Power Tube Department sales force.

Bernie P. Askew has been appointed superintendent of maintenance at The Youngstown Sheet and Tube Co.'s Campbell Works, succeeding **William T. Morris,** who has retired. Mr. Askew has been assistant superintendent since 1948. **Paul F. Schmidt,** has been named superintendent of the Maintenance Department at the Brier Hill Works. He previously was maintenance foreman at Youngstown's rod and wire mill at the Struthers plant.

William A. Klawitter has been named supervisor, magnetic and expansion alloys research, by The Carpenter Steel Co. In his new position, Mr. Klawitter is in charge of a group developing improved alloys for magnetic, glass sealing, and thermal expansion applications. He had been working as a metallurgist in the same group for the past year. Before joining Carpenter in 1959, he was employed by General Electric Co. for nine years as a metallurgical development specialist and advanced engineer in the Instrument Department.

Walter H. Shealor has been appointed assistant director of sales, international divisions of The Timken Roller Bearing Co. Mr. Shealor joined Timken in 1946 as a sales engineer trainee in the Automotive Division in Canton, Ohio. The same year, he was made a sales engineer in the Automotive Division of the company's Detroit, Mich., office. He was transferred to Washington, D. C., in 1950 and was made district manager of the Washington office the following year. In 1953,

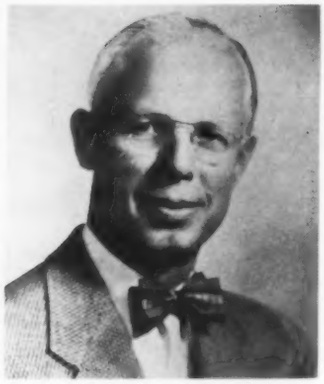
T. A. CLEARY, JR.

H. O. BEAVER

H. L. WILLKE

K. W. DUDLEY

ROBERT POTTER



J. R. PATTERSON

C. E. PETERSON

E. P. SANDBACH

he returned to Canton as assistant general manager of the company's Export Division, the position he held at the time of his present promotion.

Robert Potter, formerly president of the E. W. Bliss Co., was elected chairman of the firm's board of directors, and **J. Ralph Patterson,** formerly vice president in charge of the company's Mackintosh-Hemphill Division, was elected to the office of president and chief executive officer. Mr. Patterson was elected a director of the company at the same time. **Charles E. Peterson** has been named division manager in charge of the Mackintosh-Hemphill Division, succeeding Mr. Patterson as chief executive of the division. Mr. Peterson joined Mack-Hemp in 1954 as chief metallurgist and three years later became manager of manufacturing operations, a position which he held until his present appointment. Previously he had served at the Homestead Works of U. S. Steel Corp. and with Blaw-Knox Co. Succeeding Mr. Peterson as manager of manufacturing of the Mackintosh-Hemphill Division is **Edward P. Sandbach.** In his new position, Mr. Sandbach will be in charge of manufacturing operations at the Division's Pittsburgh and Midland, Pa., plants. Mr. Sandbach was formerly chief metallurgist for Mackintosh-Hemphill, a position he has held since 1957. Prior to his association with the E. W. Bliss organization, Mr. Sandbach was employed by United Engineering and Foundry Co., and with the Acid Open Hearth Research Association.

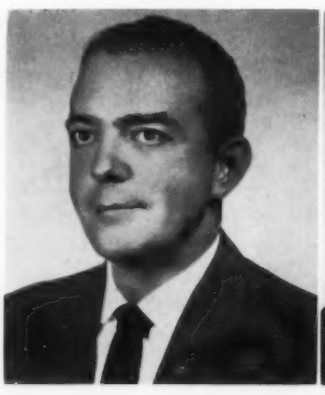
George A. Watkins has been appointed district sales representative in Los Angeles, Calif., for Heppenstall Co. and Midvale-Heppenstall Co. Mr. Watkins started with Heppenstall Co. in 1957. Since 1959 he has been assistant district sales manager for the two companies in Cleveland. Earlier he was a sales engineer for American Brake Shoe Co. and Blaw-Knox Co.

Webber I. Collart has been named manager of the new Pittsburgh, Pa., district office of Daystrom, Inc., Weston Instruments Division. He was formerly a regional specialist in the Cleveland area. **Thomas C. Odderstol** has been appointed manager of the Charlotte, N. C., district office. Mr. Odderstol previously served on the Washington, D. C., sales force. Two new branch offices have also been created, at Phoenix, Ariz., and Grand Rapids, Mich. **Walter B. Cooper**, formerly of the Los Angeles office, is now branch manager at Phoenix, and **J. Gordon Walker,** formerly of the Detroit district office, is branch manager for the Grand Rapids office.

M. M. Rand has been appointed to the newly-created position of manager of carbon electrodes and refractories for National Carbon Co., Division of Union Carbide Corp. He joined National Carbon in 1948 at the Niagara Falls development laboratory, and in 1950 transferred to the Electrode Products Technical Service Department. In 1951 he joined the Production Department, and served as a foreman at both the Niagara Falls and Columbia, Tenn., plants, rejoining the Electrode Products Technical Service Department in New York in 1954. He was named electrode sales representative in Detroit in 1955, and in 1957 was appointed Pacific division manager of electrode products. Since early this year, he has been eastern division manager of electrode products, with headquarters in Pittsburgh. **James A. Michel** succeeds Mr. Rand in that capacity. Mr. Michel joined National Carbon in 1955. Following a training period at the Niagara Falls plants, he was assigned to the Electrode Products Technical Service Department in New York. He next served as a sales representative in New England, and has most recently been an electrode products sales representative in the Pittsburgh district.

Homer Clarkson Lackey was appointed president, director, and chief executive officer, of Erie Forge & Steel Corp. From 1921 to 1942 Mr. Lackey was connected with the Midvale Co., engaged in the manufacture and sale of forgings and castings. He became district manager of sales for Midvale in Detroit and Cleveland from 1945 to 1947, and area manager of sales

M. M. RAND



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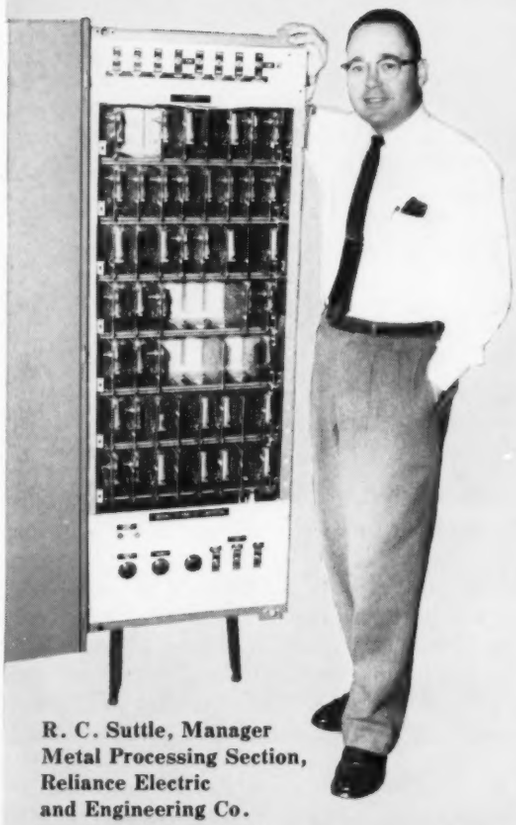

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"Precise system control for acceleration, deceleration and shearing is a vital contribution to this cut-to-length tin sheet line. A VSC voltage regulator controls acceleration on the unwind and leveler sections, and provides stepless speed changes. Unwind tension is accurately controlled by a VSR current regulator . . . and the entire drive is powered by Reliance D-c. motors.

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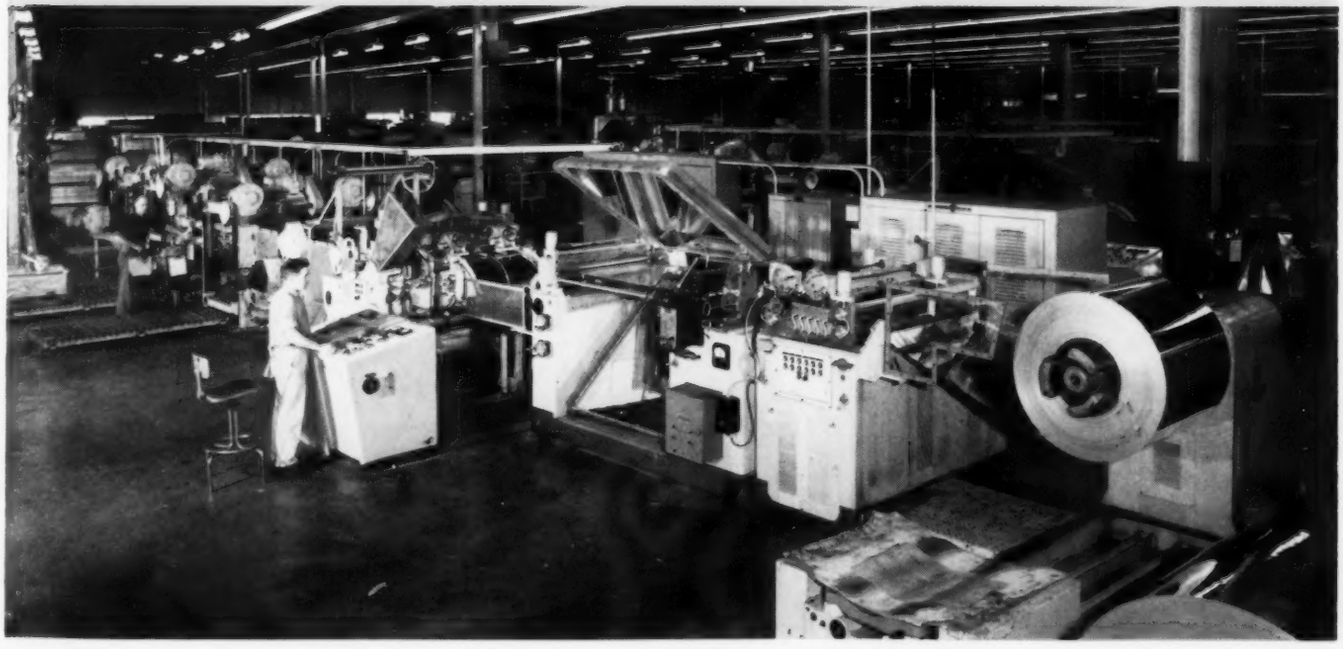


G. R. VASSILY

F. Q. WILSON

in Chicago from 1948 to 1950. He joined Carnegie-Illinois Steel Co. in 1950 as staff assistant to the general manager of sales, and since 1951, had been manager—forged products, United States Steel Corp.

George R. Vassily has been appointed sales engineer of Pittsburgh Engineering and Machine Division, Textron Inc. Mr. Vassily began his business career with the Federal Shipbuilding and Drydock Division of U. S. Steel Corp. as a test engineer. In 1946, he joined E. W. Bliss Co. as Pittsburgh area sales representative. Prior to his present appointment, Mr. Vassily was associated with Blaw Knox Co. as sales engineer.

France Q. Wilson has been appointed vice president for marketing by the Waterbury Farrel Foundry & Machine Co., Division of Textron Inc. Mr. Wilson had served previously with the Elliott Co., and with Solar Aircraft Co.

J. E. LeMay has been named manager of technical service for brush and railroad products by National Carbon Co., Division of Union Carbide Corp. Mr. LeMay joined National Carbon as a sales trainee in Cleveland in 1945, and his first field assignment was in Baton Rouge, La., from 1946 until 1949. For the next two years, he was in the Pittsburgh sales office, and then served as assistant district manager in Dallas for two years, and in a similar capacity in San Francisco for a year. In 1954, he was named division manager in Dallas, and from 1957 until his current assignment was division manager in Pittsburgh. At the same time, **John Gibb** was named mideastern division manager of brush and railroad products. Mr. Gibb joined National Carbon in 1951 in the Sales Department in Cleveland, and in 1953 was assigned to the St. Louis sales office. Since 1957 he has been a carbon products sales representative in Dayton, Ohio.

Rodney E. Hanes has been appointed vice president—operations of the Foundry & Mill Machinery Group of Blaw-Knox Co. He joined Blaw-Knox in 1952 after 12 years with U. S. Army Ordnance, which included service as chief of manufacturing at the Detroit Arsenal. Named to succeed Mr. Hanes as plant manager of the company's Wheeling Works is **Earl E. Vance**. Starting with the company's East Chicago Works in 1937, Mr. Vance has served there and at Wheeling in technical and supervisory posts, and has been general superintendent at Wheeling.

Walter J. Hegedus has been appointed field sales engineer in the Pittsburgh area by Farrel-Birmingham Co., Inc. He replaces **David Neill,** who has been transferred to the company's home offices in Ansonia, Conn., as manager of roll grinding sales.

John A. Hartzell, manager of the Coke Plant Sales Department, has been appointed a vice president in the Engineering and Construction Division of Koppers Co., Inc. Mr. Hartzell has been manager of the Coke Plant Sales Department since 1951. He joined the company in 1922 and, after serving in a number of capacities in the Engineering Department, was named assistant manager of the Coke Plant Sales Department in 1944.

C. H. Brittenham has been named manufacturing manager of the Pacific Manufacturing Division, Federal Pacific Electric Co. In his new position, Mr. Brittenham will be in charge of manufacturing operations at the company's plant in Santa Clara, Calif. Before joining Federal Pacific, Mr. Brittenham was associated with the Square D Co. as production control manager and plant manager in several locations.

Vincent R. Troglione has been elected president of Sunbeam Equipment Corp. He was formerly vice president and general manager.

Alan Auer has been appointed roll shop supervisor and assistant roll designer at Buffalo Steel Corp. Mr. Auer was formerly associated with Crucible Steel Co. of America since 1925, in various plants at both Syracuse, N. Y., and Pittsburgh, Pa.

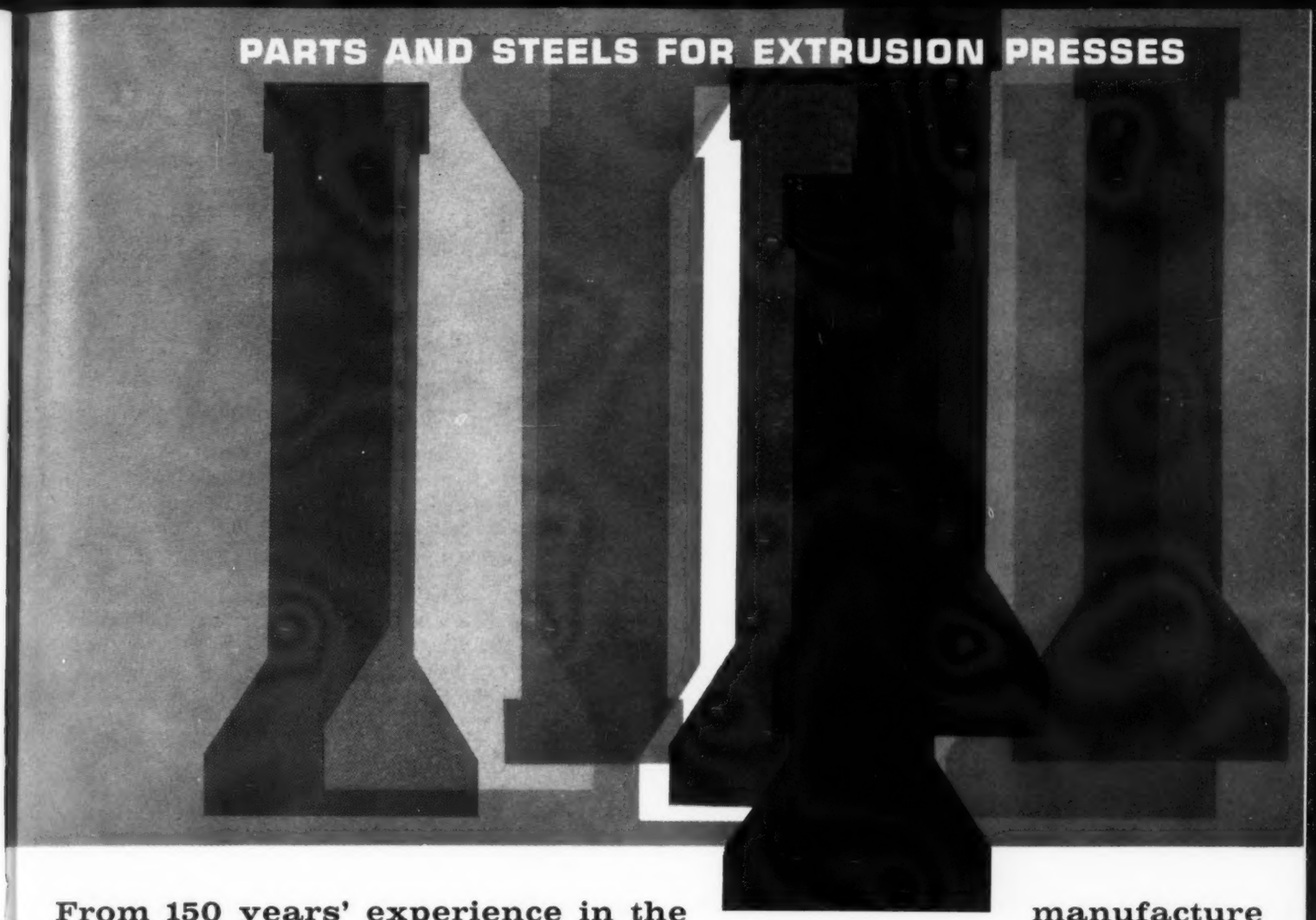
J. E. LE MAY

R. E. HANES

W. J. HEGEDUS

J. A. HARTZELL

PARTS AND STEELS FOR EXTRUSION PRESSES



From 150 years' experience in the manufacture of special steels for special uses come parts for extrusion presses by Marathon. Developed to assure excellent service life at reasonable cost, Marathon parts are precision made for each application. Our Technical Bulletin EP11 will be sent on request. Immediate attention given to your inquiries.

MARATHON

SPECIALTY STEELS, INCORPORATED

A Division of Deutsche Edelstahlwerke A. G., Krefeld, West Germany DEW 375 Park Avenue, New York 22, N. Y.

Justin S. Blay has joined Selas Corp. of America, as metallurgist. Previously Mr. Blay was associated with North American Aviation, as heat treat specialist. He has also held the position of plant manager for Alloy Surfaces Co., Metlab Co., and Metallurgical Service Co.

Kenneth Brierley has been appointed general manager of the Fall River Division, Minneapolis-Honeywell Regulator Co. **John H. Hagen** succeeds Mr. Brierley as head of the Rubicon Division. Mr. Brierley joined Honeywell's Brown Instruments Division in 1946 and has served in a number of executive and managerial capacities. Mr. Hagen has been with the company since 1933, first in Minneapolis, and since 1940 in Philadelphia.

Donald W. Sutton has been named sales engineer in the Equipment Sales Department of Dravo Corp's Engineering Works Division. Mr. Sutton joined Dravo in 1958. Most recently he served as a field engineer during construction of a new sinter plant Dravo is building for McLouth Steel Corp. at Trenton, Mich.

Kenneth Metcalfe, formerly chief metallurgist of the Bridgeville, Pa., plant of Universal-Cyclops Steel Corp., has been promoted to the position of manager of technical service of the company. At the same time, **A. Nagy,** formerly research associate, and **T. A. Felk,** formerly in the Bridgeville plant metallurgical laboratory, have been appointed to the position of metallurgical engineers, technical service.

KENNETH METCALFE

G. S. ARNESON

George S. Arneson has been appointed director of marketing for the Delta-Star Electric Division of H. K. Porter Co., Inc., Mr. Arneson was formerly director of marketing, and general manager of the Borg-Warner Capital Equipment Manufacturing Division.

Edward A. Puchalski has been named sales manager for Milwaukee Crane, a division of Novo Industrial Corp. Mr. Puchalski joined Milwaukee Crane in 1952 as a design engineer and has been active in engineering and sales for the past five years.

R. C. Bown has been appointed manager of sales, Allis-Chalmers Manufacturing Co.'s Control Department. He succeeds **G. G. Brooks,** who has been transferred to Allis-Chalmers associate company, Consolidated Systems Corp., where he will be in charge of

EXECUTIVE REPORT #30

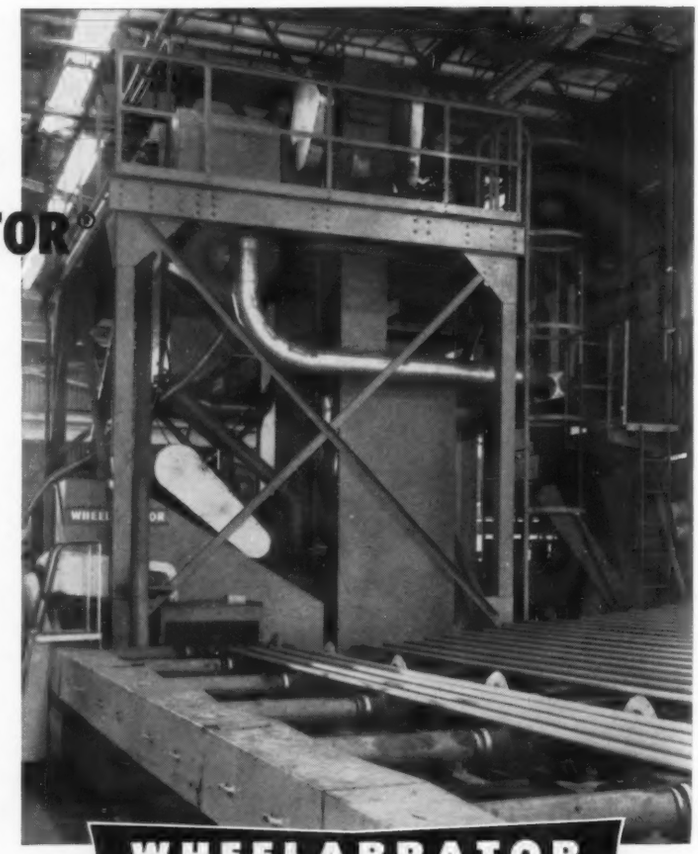
AUTOMATED DESCALING WITH THE WHEELABRATOR®

The bar stock cleaning line in the new two million dollar Elyria, Ohio, Cold Draw plant of The Western Automatic Machine Screw Co., Div. of Standard Screw Co. utilizes one of six Wheelabrator descaling machines that have completely eliminated pickling in this modern plant.

On the bar line, the Wheelabrator enables one man to handle the entire operation, from receipt of bar bundles, through an unscrambler, transfer to feed roll conveyors, through the Wheelabrator, and out onto a storage rack in line with the draw bench. For over 16 months of operation, round, square and hex bar stock, up to 4½" diameter in 15' to 45' lengths, has been descaled without any of the old acid pickling headaches. In addition, Western Automatic reports that Wheelabrator descaling provides a definitely superior product for subsequent cold drawing.

How To Automate Your Bar and Wire Drawing Lines

Details of Wheelabrator's cost-saving descaling method are illustrated in Bulletin 148-D. Write to Wheelabrator Corp., 396 S. Byrkit St., Mishawaka, Indiana. In Canada, P.O. Box 490, Scarborough, Ontario.



WHEELABRATOR
AIRLESS BLAST EQUIPMENT

industrial systems. Succeeding Mr. Bown as manager of Allis-Chalmers rectifier section is **W. G. Williams.** Mr. Bown has been with Allis-Chalmers since 1946. He was a sales representative in the St. Louis district; manager of the Evansville district; manager of General Products Division sales, Midwest Region; and assistant manager of the rectifier section before becoming manager of the section in early 1960. Mr. Brooks was supervisory engineer for standard starters from 1955 to 1958 when be became manager of product sales in the Control Department. Mr. Williams was successively a sales engineer in the Industrial Systems Department and in the rectifier section before becoming engineer-in-charge of induction and dielectric heating sales in 1957, and manager of product sales in the rectifier section early this year.

William Bailey III has been named vice president, sales for Jackson Industries Inc. in Birmingham, Ala. Mr. Bailey was formerly assistant sales manager of Stamco, Inc.

E. Lincoln Van Sickel has joined the Penn Machine Co., as assistant to the executive vice president. He was formerly a Pittsburgh representative of the Tool Steel Gear and Pinion Co.

Dr. Robert F. Patrick was appointed research manager for steel refractories in the Ceramic Research Division of Corning Glass Works. Dr. Patrick joins Corning after having been associated with the Pemco Corp. for the past 11 years. He had served there as assistant director of research since 1952.

They say PROVINCIAL Engineering Ltd. builds the finest cranes in Canada

Yeah-And they'll be building them in the year 2000!

EXECUTIVE REPORT #4

HEALTHY MOTORS BREATHE ULTRA-PURE AIR

...cleaned by **WHEELABRATOR**® air filters

Your investment in steel making equipment is too big to take a chance on motor failure resulting from dust in the atmosphere. Especially when Wheelabrator Ultra-Filtration air filters can provide essential air purity at minimum cost.

In prominent American and Canadian steel plants, Ultra-Filtration today is providing over 5,000,000 cfm of super-clean air for motor rooms, control rooms, electrical equipment and turbo blowers.

The low cost of operating Wheelabrator Ultra-Filtration air filters is gratifying, too. No liquids, oils or tacky materials are involved — there is no problem of sludge removal. In one typical installation, *absolutely* no maintenance cost has been experienced in filtering over 394,000 000,000 cf of air.

Ultra-Filtration provides any degree of air purity you require, at minimum cost

Ultra-Filtration delivers collection efficiencies above 99% by weight and 95% by blackness test, even when filtering sub-micron size particles. For illustrations of highly efficient Dustube installations, write for Catalog 562-D. Wheelabrator Corp., 396 S. Byrkit St., Mishawaka, Ind. In Canada, P. O. Box 490, Scarborough, Ont.

WHEELABRATOR
DUST AND FUME CONTROL

Warmth for isolated workers

IN PULPITS...

CRANE CABS...

ORE BRIDGES... ELSEWHERE

THE
LINTERN HEATER

Circulates... Ventilates

The Lintern Heater takes less space and yet provides more effective heat distribution than any heater previously offered for crane cabs, watchmen's shanties and similar confined areas. An optional filter is available where dirt is a problem. Installs on ceiling, wall or floor. Low in cost, compact in size, light in weight, highly dependable. Available in all AC or DC voltages.

Write for full information

Larco, inc.

Distributor of Lintern Corporation Products
Route 20 East, Painesville, Ohio

J. E. ZWIT

W. H. BOYCE

Joseph E. Zwit was named sales manager for Hauck Manufacturing Co.'s Engineering Division. Mr. Zwit joined Hauck's Chicago district sales office in 1956. A year later he was appointed central regional manager.

William H. Boyce was appointed executive vice president of Royal Electric Manufacturing Co. Mr. Boyce will be in charge of the firm's Industries Division of Royal Electric. He joined Royal from Delta-Star Electric Division, H. K. Porter Co., Inc.

Obituaries

Walter P. Schmitter, engineering vice president of The Falk Corp., died September 5. He was 62. Associated with Falk since 1924, he was previously employed by Cutler-Hammer, Allis-Chalmers and the American Machine and Foundry Co., and at one time was a consulting engineer in special machine design.

Michael B. Egan died August 30. For the past several months Mr. Egan was associated with H. B. Stallings & Associates, Wallingford, Pa., he was formerly a sales engineer with the Clark Controller Co.

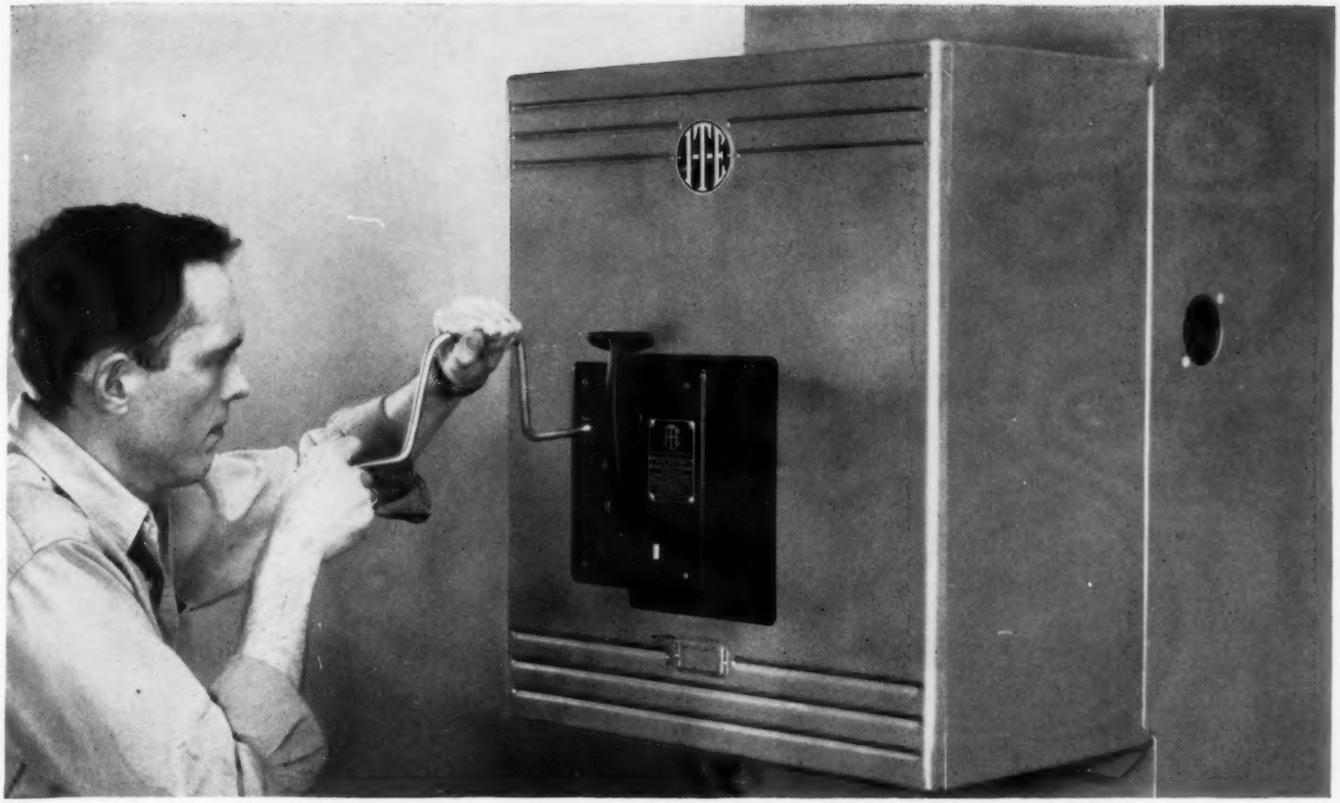
Lee F. Ravey, assistant director of purchases for The National Supply Co., died August 20. He was 62.

Dr. Harry K. Ihrig, 62, vice president in charge of research for Allis-Chalmers Manufacturing Co., died August 22. Prior to joining Allis-Chalmers in 1950, Dr. Ihrig had been associated with Globe Steel Tubes Co. for 16 years as director of laboratories and vice president.

Call or Write STAMCO for...

Slitting and Coiling Lines
Cut-to-Length Lines
Flying Shear Lines
Power Squaring Shears • Automatic Resquaring • Corrugating
Culvert • Steel Mill Equipment

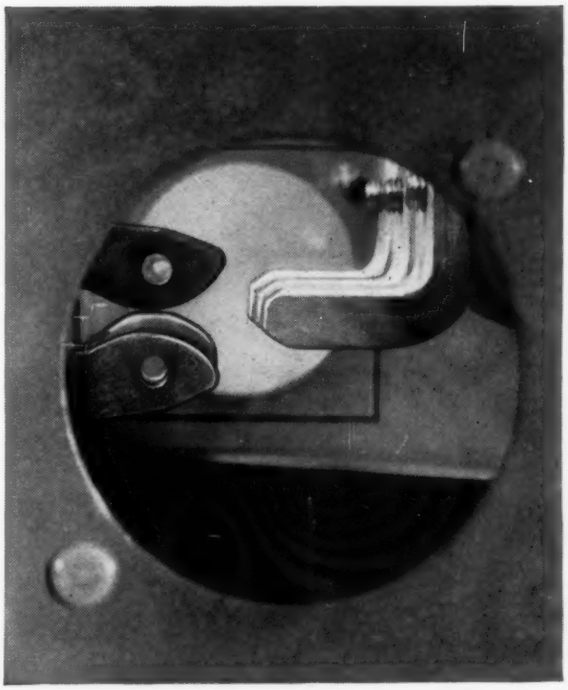
STAMCO, Inc., New Bremen, Ohio



Urelite® gives you double safety

Exclusive with I-T-E

Independent drawout design
Visible separable contacts



In an individually enclosed large air circuit breaker, you couldn't ask for more safety than the I-T-E URELITE gives you. To disconnect it, just insert the crank at the front and turn. Cover need never be removed. A look through the side window positively shows you the position of the separable contacts. Also, with the circuit breaker open, it can be padlocked safely in either connected or disconnected position.

The whole truth is that URELITE breakers are unmatched for exclusive safety provisions, and for low-cost installation, easy access, longer contact life, and adjustable overload devices for higher loads. They handle circuits up to 600 volts, 15 to 4000 amp continuous and 150,000 amp interrupting. Write for new bulletin 4261-2B. I-T-E Circuit Breaker Company, Dept. LA, 1900 Hamilton St., Philadelphia 30, Pa.

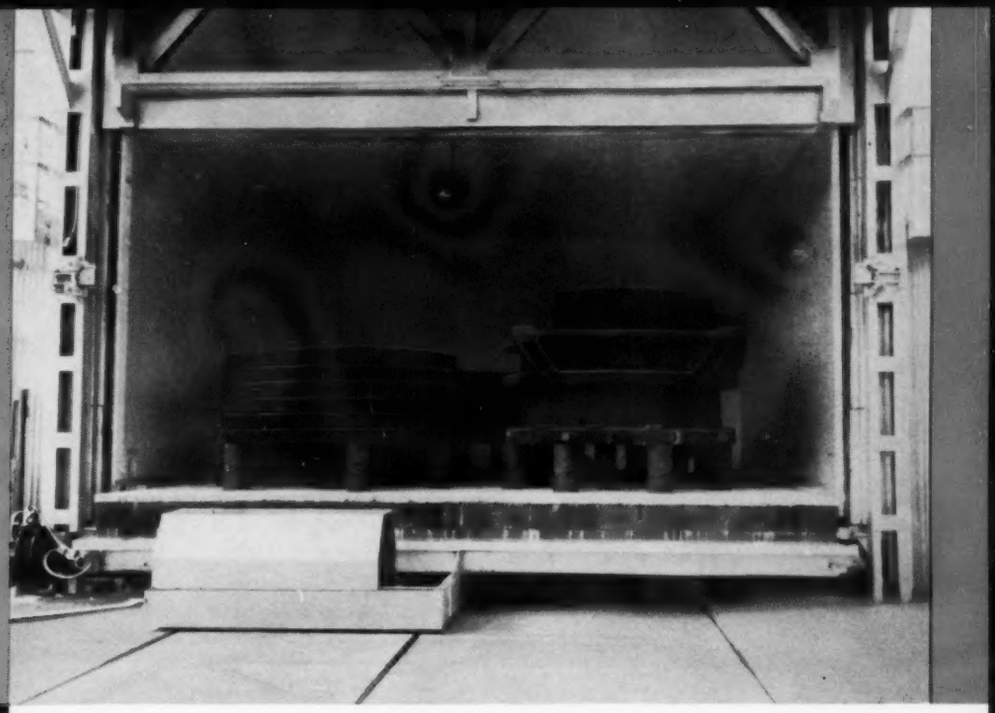
I-T-E CIRCUIT BREAKER COMPANY

SWINDELL

CAR-BOTTOM FURNACES

provide high capacities, high temperatures, and close firing control for the most exacting steel heat-treating requirements

Engineering Service Swindell-Dressler Corporation provides a complete engineering service for the steel industry in the design and construction of new plants, and modernization of existing facilities. Consultations arranged gladly on request.



With a lift-type door at each end, this Swindell furnace has provision for the car to be operated from either end. Interior dimensions are 24′ wide by 30′ long with a loading height of 10′ and a furnace chamber 14′ high. The car, which is provided with a self-propelled drive unit, is designed for a 100-ton load. The maximum operating temperature is 2000°F.

These two Swindell car-type furnaces heat-treat a great variety of cast and welded products. Each furnace is 10′ wide by 42′ long, with a 10′ loading height from the top of the car deck. The cars, each driven by a rack and pinion drive mechanism, are designed to carry individual loads of 250 tons. The maximum furnace temperature is 2000°F. • For consultation on your heat-treating or other metal processing furnace requirements, call Swindell-Dressler.

SUBSIDIARY OF PULLMAN INCORPORATED

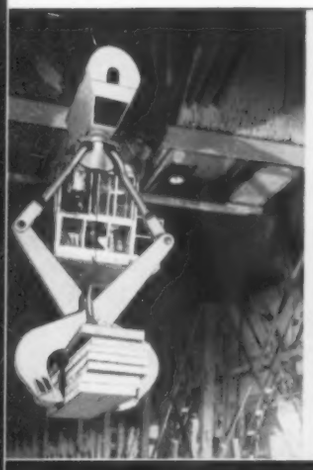
SWINDELL-DRESSLER CORPORATION

Engineers and Manufacturers

PITTSBURGH 30, PA.

The SWINDELL-DRESSLER CORPORATION of Canada, Ltd.,
Ottawa, Canada

TONGS put a tight grip on safety and economy



The tong jaws open to 76½ inches. They are operated by a separate hoisting unit with cable connected to the pivot point of the tongs.

The cab on these cranes is air-conditioned for operator comfort. It is supported from and travels with the trolley overhanging the rear girder.

Inland Steel Company gave up chains, spacers, and "hooker" manpower in piling slabs in No. 2 Slab Yard at East Chicago, Ind. Time proved the method unsafe for both "hooker" and crane, and inefficient as well. The chains often hung-up and had to be pulled free by the crane operator. Haphazard piling also robbed the yard of storage space.

Inland Steel's plant engineers and Shaw-Box engineers solved the problem. Now five "Shaw-Box" Cranes with unique tongs handle an average of 60,000 tons of slabs a week. They are 120-foot span cranes with 50 and 25 ton hooks, each with a lifting speed of 40 FPM. All slab piling is handled from the cab which travels with the trolley. Slabs are piled far neater than before, and many more can be stored in the same area.

Since their erection in 1957, all five cranes have proved their quality in dependable service. The same creative engineering has made great problem solvers of all types of Shaw-Box Cranes, whether built to AISE specs or individual standards of construction and performance. We welcome the opportunity to serve you.

MANNING MAXWELL & MOORE INC. TRADE MARK

60 K-1

SHAW-BOX® CRANES

A product of

MANNING, MAXWELL & MOORE, INC.

Shaw-Box Crane & Hoist Division • Muskegon, Michigan
In Canada: Manning, Maxwell & Moore, Ltd., Galt, Ontario

Penetrascopes and Shore Model "C" scleroscopes testing hardness after rehardening.

Rehardened rolls precision ground and finished to required tolerances.

Worn rolls being pre-tested with reflectoscope for surface and under-surface defects before hardening.

rehardened rolls

THE TSP WAY SAVES YOU MONEY

TSP rehardening saves money by prolonging the life of the roll 2 to 3 times. Each rehardening is made at a fraction of the cost of a new roll.

TSP rehardening saves money on inventories because worn rolls are rehardened in a fraction of the time required to make and deliver a brand new roll. This fast processing allows continuous operation with a lower inventory of rolls.

TSP remaking saves money by further extending the life of the roll even when it is worn below the minimum requirements for the mill. This is accomplished by remaking the roll for a smaller mill at a fraction of the cost of a new roll.

The Tool Steel Gear and Pinion Co. has long been the leader in the field of rehardening and remaking of cold rolling rolls. An outstanding staff of metallurgists work with the most modern heat treating facilities. Rolls are rehardened to the exact hardness required for best performance in customers operation. Hardness achieved in excess of 900 DPH or 95-100 Scleroscope. Two modern plants equipped for ultra precision grinding and finishing, assures production of rehardened or remade rolls of superb quality.

Write for Bulletin 158 "Important Facts About TSP Rehardening and Remaking of Cold Rolling Rolls."

THE TOOL STEEL GEAR AND PINION CO.
CINCINNATI 16, OHIO, U. S. A.

MEMBER OF AGMA

AD 1033

The Standard of Quality Since 1909 for Gears • Pinions • Rolls • Wheels and Other Hardened Products

. . . For Modern Regenerative Soaking Pits . . .

A leading midwest Steel Mill selected Morgan-Isley Systems for their improvement program on twenty holes of regenerative soaking pits. Part of the Morgan-Isley Systems were installed to provide additional capacity—part of the installation modernized old regenerative pits—part replaced one way fired pits. The fuel used throughout is coke oven gas.

MORGAN WORCESTER

The illustration shows the Morgan-Isley Systems with Secondary Checkers installed on Six of the Twenty Hole installation.

For Efficient Operation, Cost Saving Qualities, Accurate Regulation use this Modern System—Phone, wire or write . . .

CCC 60

MORGAN CONSTRUCTION COMPANY WORCESTER, MASSACHUSETTS

ROLLING MILLS • MORGOIL BEARINGS • WIRE MILLS • REGENERATIVE FURNACE CONTROL • EJECTORS • GAS PRODUCERS

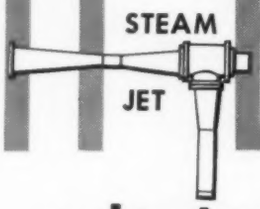
VICTOR R. BROWNING
MILL TYPE CRANES

to Specification..

Basically designed as required by A.I.S.E. specifications, mill type cranes built by Victor R. Browning & Co., Inc. also offer the opportunity of specifying preferences and standards prevailing in the purchaser's plant. May we have your next inquiry?

VICTOR R. BROWNING & COMPANY, Inc.
WILLOUGHBY (CLEVELAND), OHIO
DESIGNERS AND BUILDERS OF ELECTRIC OVERHEAD TRAVELING CRANES AND HOISTS AND ELECTRIC REVOLVING CRANES

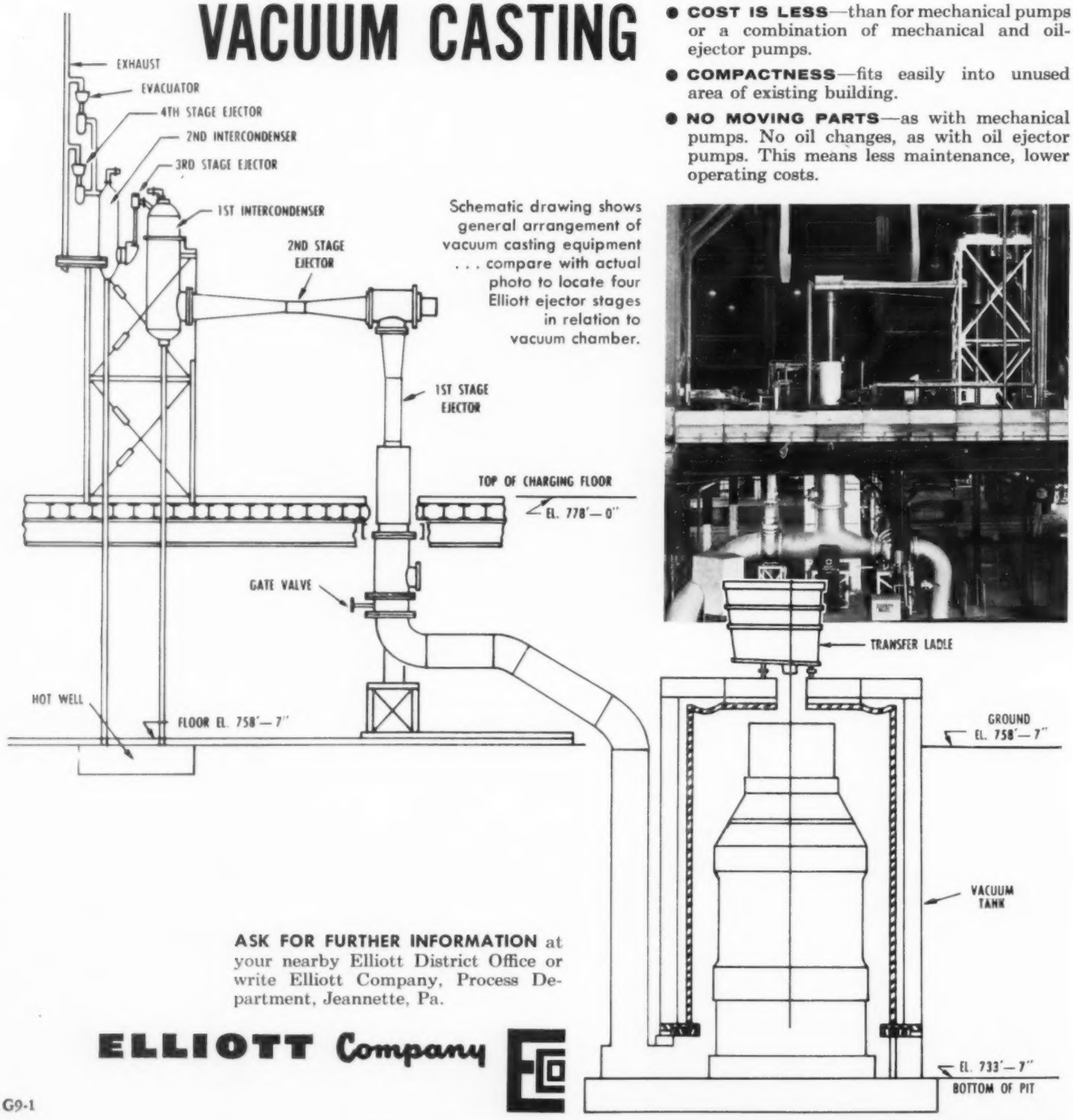
ELLIOTT EJECTORS



selected by United States Steel for VACUUM CASTING

This simplified method of removing unwanted gases assures stronger, more uniform forgings and reduced flaking and embrittlement. One of the several production-size degassing operations served by Elliott steam-jet ejectors is the United States Steel Corporation installation seen here. A 36-in. four-stage ejector system, it was selected because:

- **COST IS LESS**—than for mechanical pumps or a combination of mechanical and oil-ejector pumps.
- **COMPACTNESS**—fits easily into unused area of existing building.
- **NO MOVING PARTS**—as with mechanical pumps. No oil changes, as with oil ejector pumps. This means less maintenance, lower operating costs.



Schematic drawing shows general arrangement of vacuum casting equipment . . . compare with actual photo to locate four Elliott ejector stages in relation to vacuum chamber.

ASK FOR FURTHER INFORMATION at your nearby Elliott District Office or write Elliott Company, Process Department, Jeannette, Pa.

ELLIOTT Company

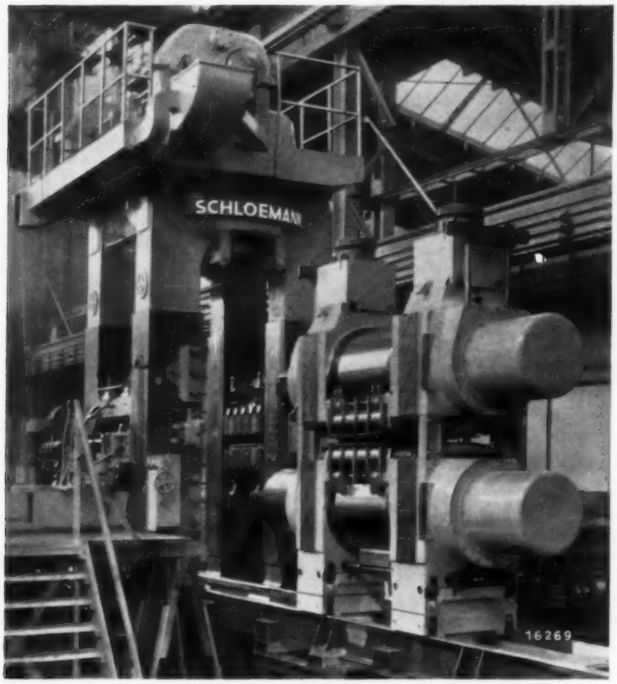
G9-1

UDC 621.944.9

SCHLOEMANN
ROLLING MILLS · HAMMERS · PRESSES

Multi-purpose rolling mill for "refractory" materials

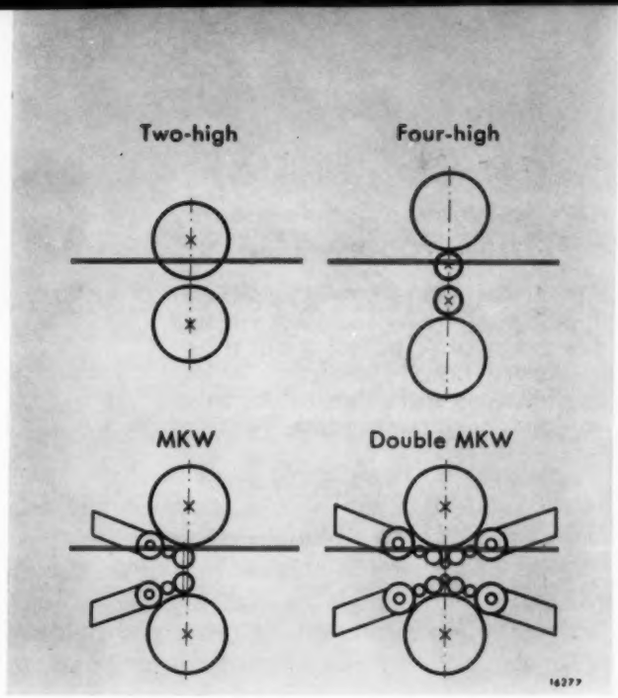
Special alloys for the nuclear power and other industries have presented extraordinary problems. The new MKW mill (US and foreign patents) developed by SCHLOEMANN is ideally suited for rolling these refractory materials and is readily adaptable



MKW 80 during workshop assembly. Above, the double MKW set-up is seen in run-out position; below, the view from the entry side shows the pay-off reel and coiler.

for conventional rolling work. Typical characteristics as included in the specifications of an MKW mill recently built for operation in the United States are as follows:

Hot and cold rolling – Initial thickness up to 2" Final thickness of strip – .006" standard; .001" min. Rolling force – in excess of 2200 tons at 24" strip width (twice the roll separating force required for rolling of conventional CrNi steels).



Four different roll set-ups for one mill:

Two-high set-up: 36" ∅ rolls

Four-high set-up: 16 1/2" ∅ driven work rolls

MKW set-up: 36" ∅ driven back-up rolls, 5" to 5 1/2" ∅ work rolls

Double MKW set-up: 36" ∅ driven back-up rolls, 2" to 2 1/4" ∅ work rolls

Wide working range

The mill is equipped with four different roll set-ups and is thus provided with an extremely wide working range. Since the new super high-grade but difficult-to-work materials are currently required in comparatively small quantities only, the use of one MKW mill with four different roll set-ups offers practical and economical advantages.

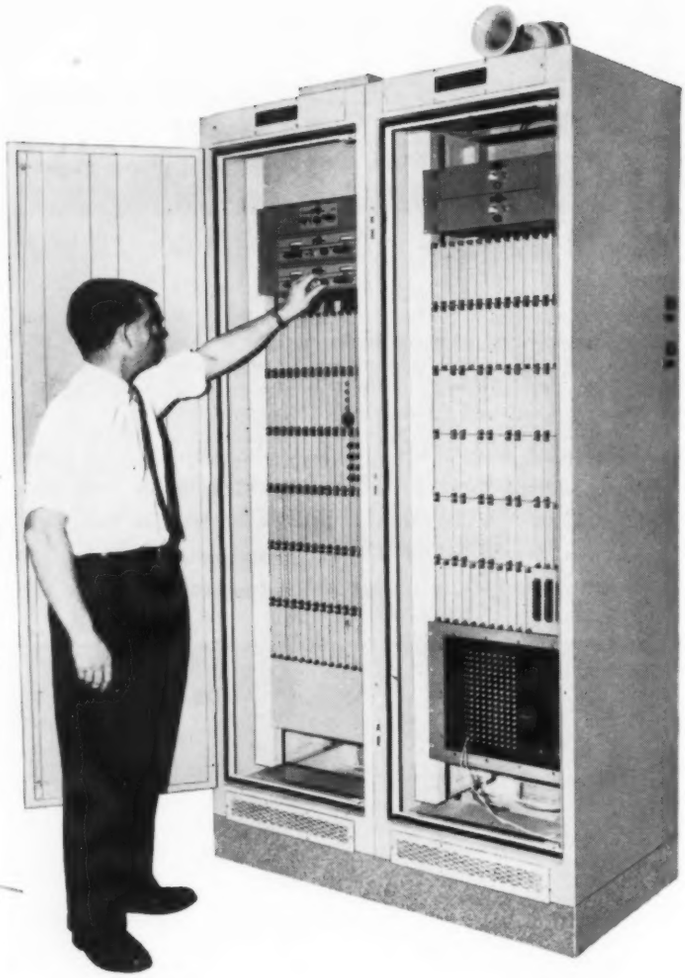
FELLER ENGINEERING COMPANY 1161 Empire Building, Pittsburgh 22, Pa.

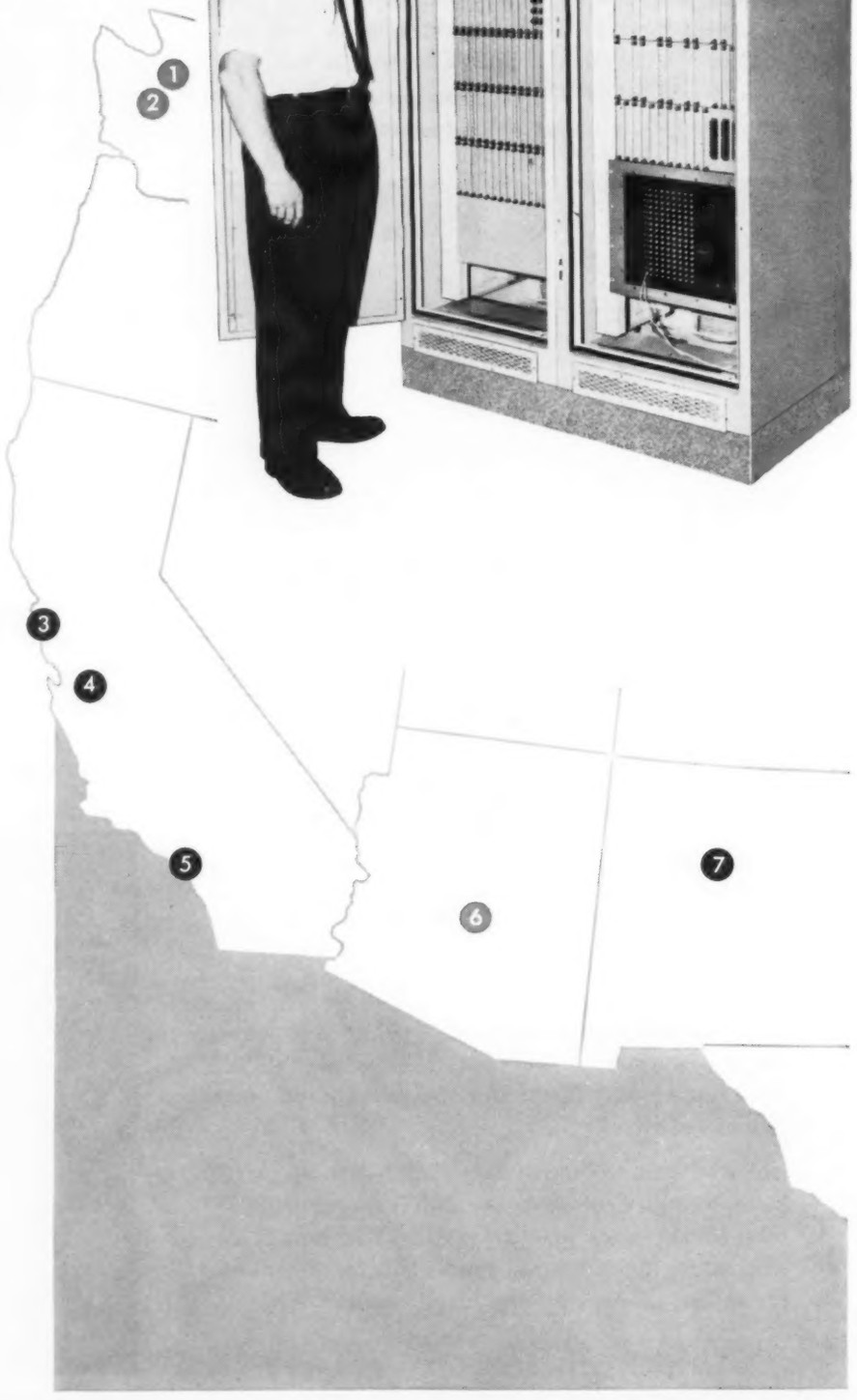
KEY to functions performed by Bailey 700 Systems

A — Analog **A/D** — Analog and Digital
D — Digital **s** — sense and measure
d — display (indicate, record and/or log)
m — monitor (scan and alarm)
p — produce stored information for future use (tape, cards) **c**—compute **r**—control

● Installed ● On order

LOCATION	TYPE	FUNCTIONS
1. Chelan Co., Wash.	D	sdm
2. Chelan Co., Wash.	D	sd
3. San Francisco	A	sdc
4. Salinas, California	A	sdc
5. Los Angeles	A	sdc
6. Glendale, Ariz.	A	sdc
7. Alameda, N. M.	A	sdc
8. Amarillo, Texas	A/D	sdmc
9. Smithers Lake, Tex.	A	sdr
10. Orange Co., Tex.	A/D	sdmcr
11. Bronte, Tex.	D	sdm
12. Sioux Falls, S. D.	A	sdr
13. Oklahoma City	A	sdc
14. Harrah, Okla.	A	sdc
15. Muskogee, Okla.	A	sdc
16. Lafayette, La.	A	sdc
17. Jackson, Miss.	A	sdc
18. Cleveland, Miss.	A	sdc
19. Memphis, Tenn.	D	sdm
20. Paducah, Ky.	D	sdc
21. Sullivan, Ind.	A	sdc
22. Graham, W. Va.	A	sdc
23. Ashtabula, Ohio	A	sdc
24. Monroe, Mich.	A	sdcr
25. Rochester, N. Y.	A	sdc
26. Ludlowville, N. Y.	D	sdmp
27. Buchanan, N. Y.	A	sdr
28. Fairless Hills, Pa.	D	dm
29. Wilmington, Del.	D	dm
30. Washington, D. C.	D	dp
31. Hamilton Twp., N. J.	A	sdr
32. N. S. Savannah	A	sdr





BAILEY 700

ANALOG AND DIGITAL SYSTEMS IN ACTION

Installed or under construction, Bailey 700 Analog and Digital Systems are IN ACTION TODAY from coast to coast, providing integrated instrumentation systems accurately tailored to specific needs.

Note the variety of functions performed in these installations. Basic ingredients of all are electronic modules housed in standardized electrical cabinets, as shown here. This permits any combination of control, information or computing system elements to be combined and expanded as required to perform specific functions in individual installations. Wiring and maintenance is simplified —operator's console is freed of bulky equipment.

Ask your local Bailey engineer to arrange a visit and demonstration of a Bailey 700 System located near you, or at Cleveland. Or get IMMEDIATE details on the installation of greatest interest to you, by TWX—just jot down the number of the location you select on message form below and hand to your secretary. Reply will be transmitted at end of your message.

G153-2

QUICK FACTS BY TWX . . .

For name and IMMEDIATE details on installation of greatest interest to you, fill in number of location from map and have your TWX operator send this message:

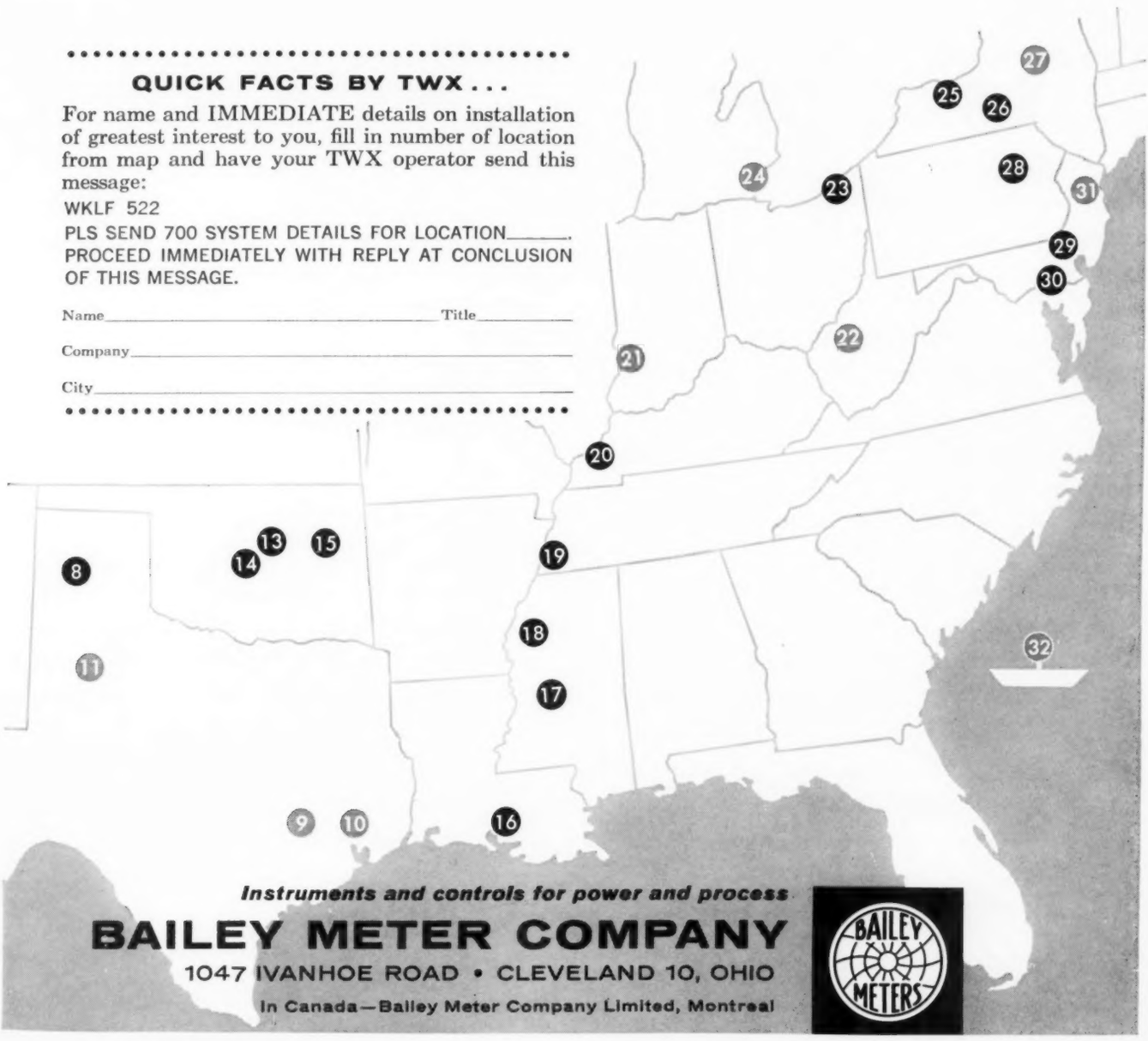
WKLF 522

PLS SEND 700 SYSTEM DETAILS FOR LOCATION_____. PROCEED IMMEDIATELY WITH REPLY AT CONCLUSION OF THIS MESSAGE.

Name_____ Title_____

Company_____

City_____



Instruments and controls for power and process

BAILEY METER COMPANY

1047 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS

WHERE DO YOU STAND ON COMPUTER CONTROL— LEADING OR LAGGING?

Far-sighted leaders in industry are realizing the benefits made possible by applying computer control systems to their processes.

Working with these leaders, General Electric has already pioneered the application of twenty on-line GE-312 computer systems now being implemented in these basic areas —STEEL, ELECTRIC UTILITIES, CHEMICAL, CEMENT, and PRODUCTION CONTROL for various manufacturing applications.

The GE-312 Computer Control System embodies adaptability and flexibility to meet many types of applications in varying size plants. For example, compare its expansible memory—capacity up to 52,000 words. Compare its flexible input/output—capable of scanning up to 1500 instrument inputs. These are maximum capabilities, expansible from a minimum system. You buy a system tailored to your exact requirements.

Add to this versatile equipment the computer systems engineering ability demonstrated by General Electric in implementing these twenty GE-312 system applications.

Add also the long history of General Electric overall systems know-how—its broad background in the equipment, processes and materials to which you apply computer control.

Tomorrow's profits will come from today's combination of vision, equipment, and know-how. *Where do you stand?*

There are General Electric Sales and Application engineers in over one hundred offices throughout the nation to serve you. *Phone* the nearest General Electric Apparatus Sales Office, or *wire* General Electric Computer Department, 13444 North Black Canyon Highway, Phoenix, Arizona.

PROCESS CONTROL
AUTOMATED BY GENERAL ELECTRIC

Progress Is Our Most Important Product

GENERAL ELECTRIC

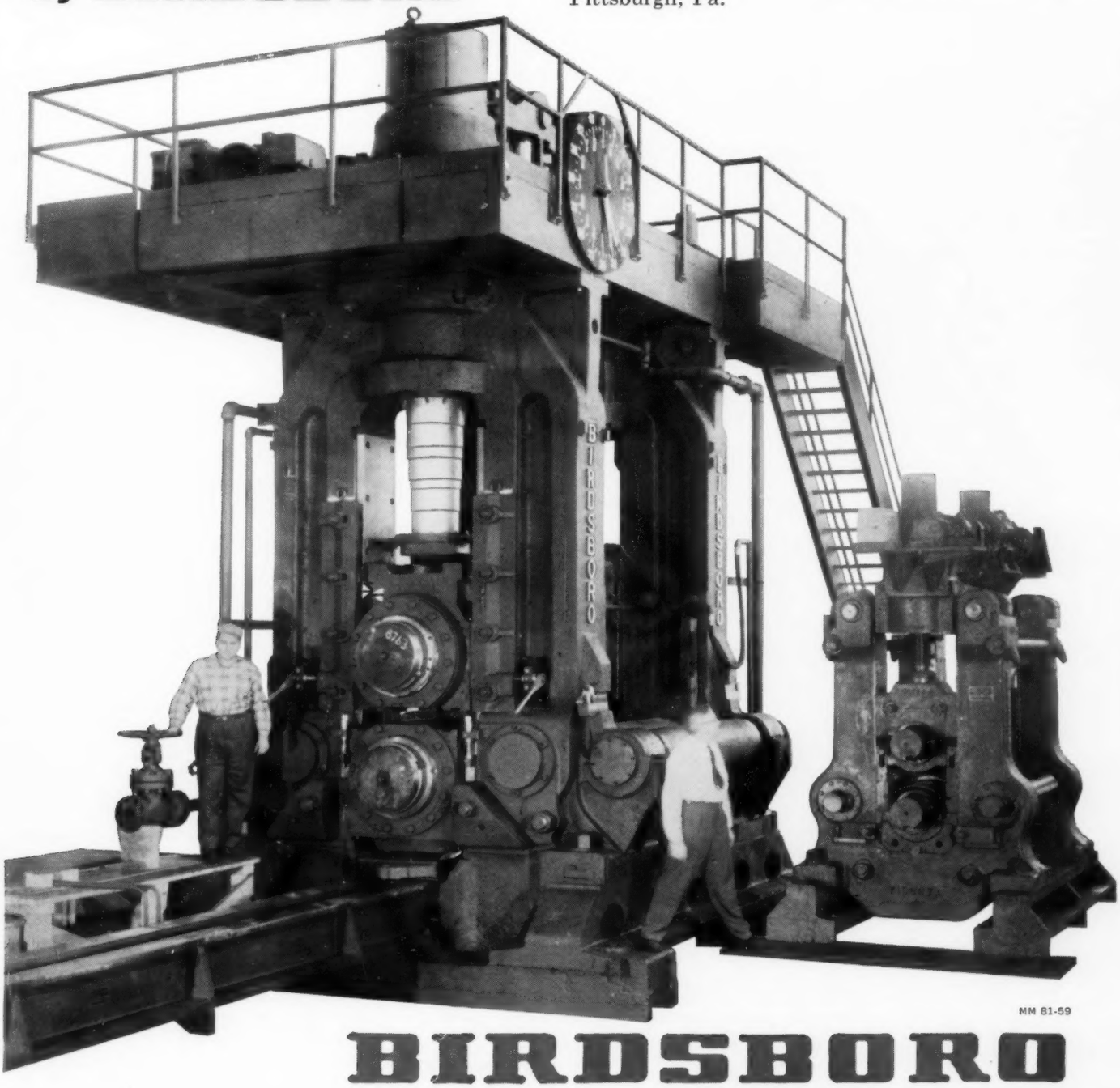
CPA-50 (5-60)

General Electric—a pioneer in computer systems for all phases of business, industrial, scientific, engineering, and financial endeavor.

A pair of Reversing
2-High Rolling Mills
—36" and 18"—
Equal in design advancements, quality and workmanship
***—by* BIRDSBORO**

For two different clients, for two different jobs, but they were produced side-by-side . . . each a product of Birdsboro's broad experience . . . experience that covers the many sizes and types of rolling mills and all their variations.

Regardless of variation, one factor remains the same, each mill is the successfully combined effort of the builder and the buyer—the experienced mill designer and the user. Each offers invaluable contributions to the successful operation of the installed unit. Each points the way to profitable productivity. *Sales Department, Engineering Department and Mfg. Plant:* Birdsboro, Pa., *District Office:* Pittsburgh, Pa.



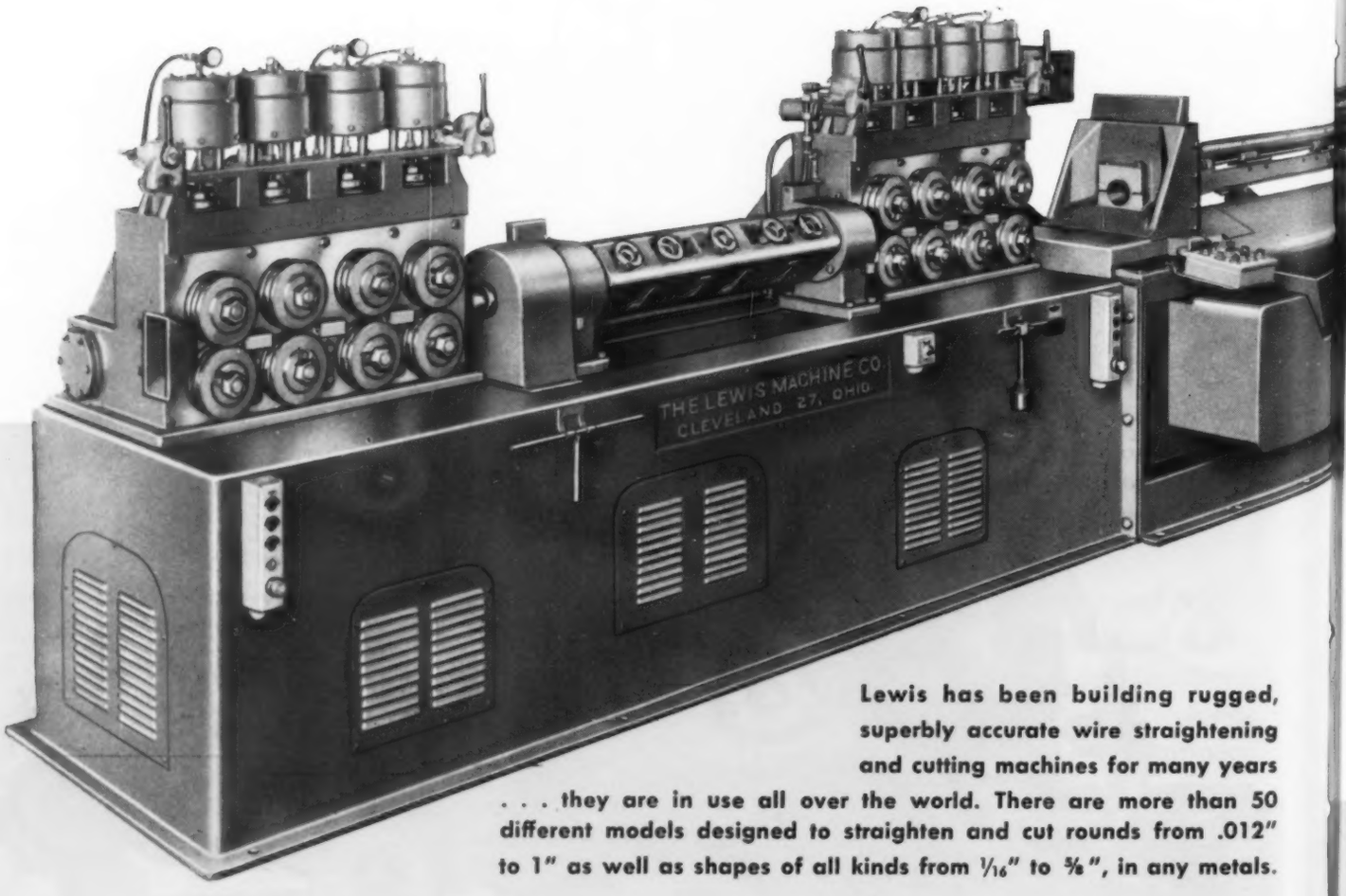
MM 81-59

BIRDSBORO
CORPORATION

STEEL MILL MACHINERY • HYDRAULIC PRESSES • CRUSHING MACHINERY • SPECIAL MACHINERY • ROLLS • ELECTRIC STEEL CASTINGS: Carbon, Low Alloy and STAINLESS STEEL

meet the ALL NEW LEWIS "TRAVEL CUT"

WIRE STRAIGHTENING and CUTTING MACHINE



Lewis has been building rugged, superbly accurate wire straightening and cutting machines for many years . . . they are in use all over the world. There are more than 50 different models designed to straighten and cut rounds from .012" to 1" as well as shapes of all kinds from 1/16" to 5/8", in any metals.

THE LEWIS MACHINE COMPANY

A DIVISION OF CURTIS MFG. CO.

3441 East 76th Street, Cleveland 27, Ohio

. . . . handles 1" rod, FROM THE COIL

LEWIS No. 12-FA

"TRAVEL CUT" WIRE STRAIGHTENING AND CUTTING MACHINE Capacity ½" to 1" dia., in either cold drawn or hot rolled rod. Eight feed speeds from 115 - 350 RPM. Cut-off or straightener units only can be supplied.

The machine you see illustrated is probably the biggest, most powerful wire straightening and cutting machine in the world . . . it has to be to handle 1" rod direct from the coil. It was designed and built by The Lewis Company and is in use by one of the world's leading steelmakers.

The Lewis No. 12-FA "Travel Cut", to give it the proper designation, is a giant in the machine world being 85 feet long and weighing over 46,000 pounds . . . it has to be big and tough because it has a big job to do.

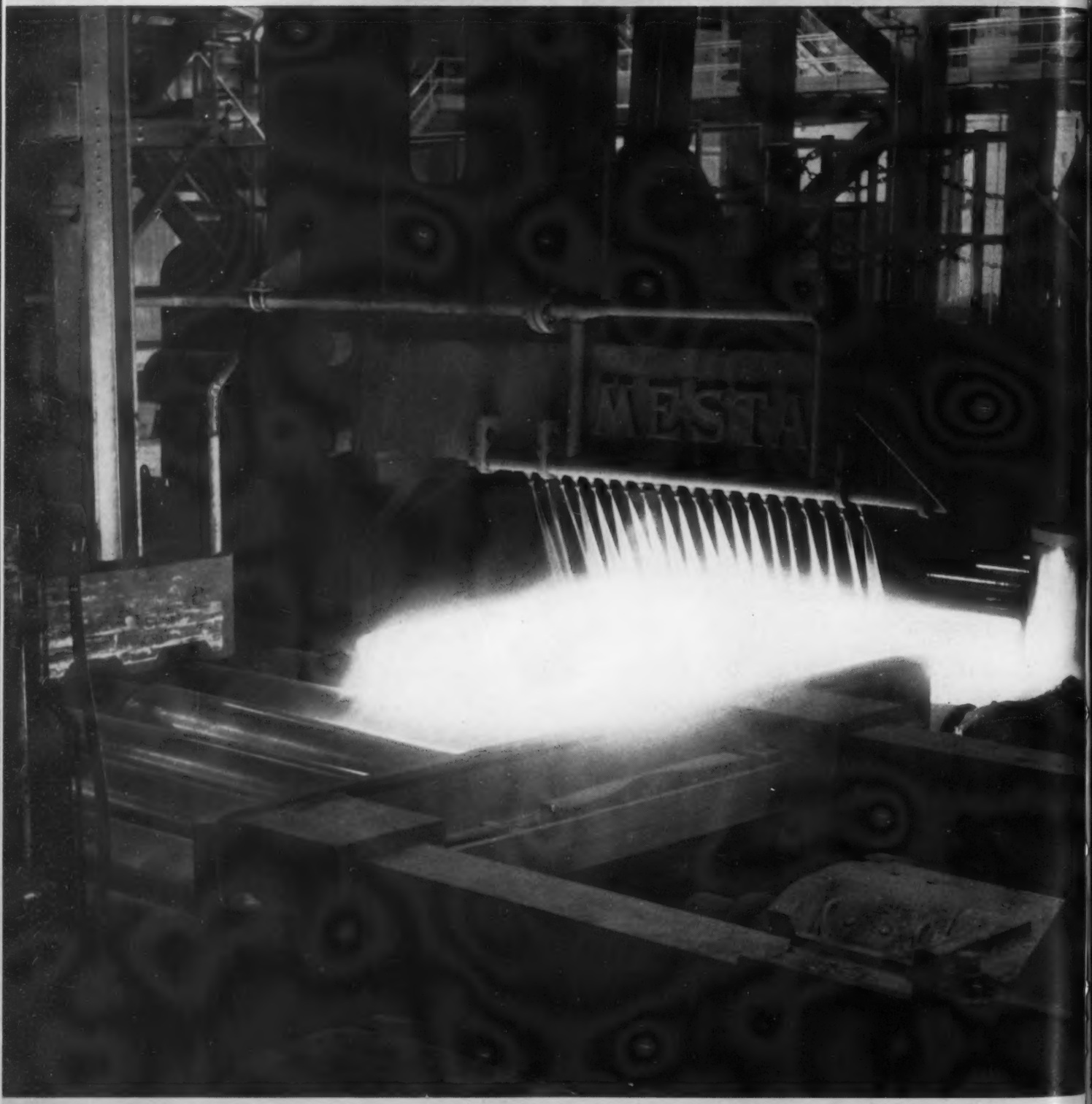
Tapered Roller TIMKEN BEARING EQUIPPED

INCREASED PRODUCTION WITH LESS SCRAP OVER DRAW-BENCH METHOD

We'll be pleased to send you our brochure showing the Lewis line of wire straightening and cutting machines. If you have any special problems in this field, our Engineers will be happy to co-operate with you in working out a solution.

DE LAVAL
CENTRIFUGAL PUMPS

for high-pressure

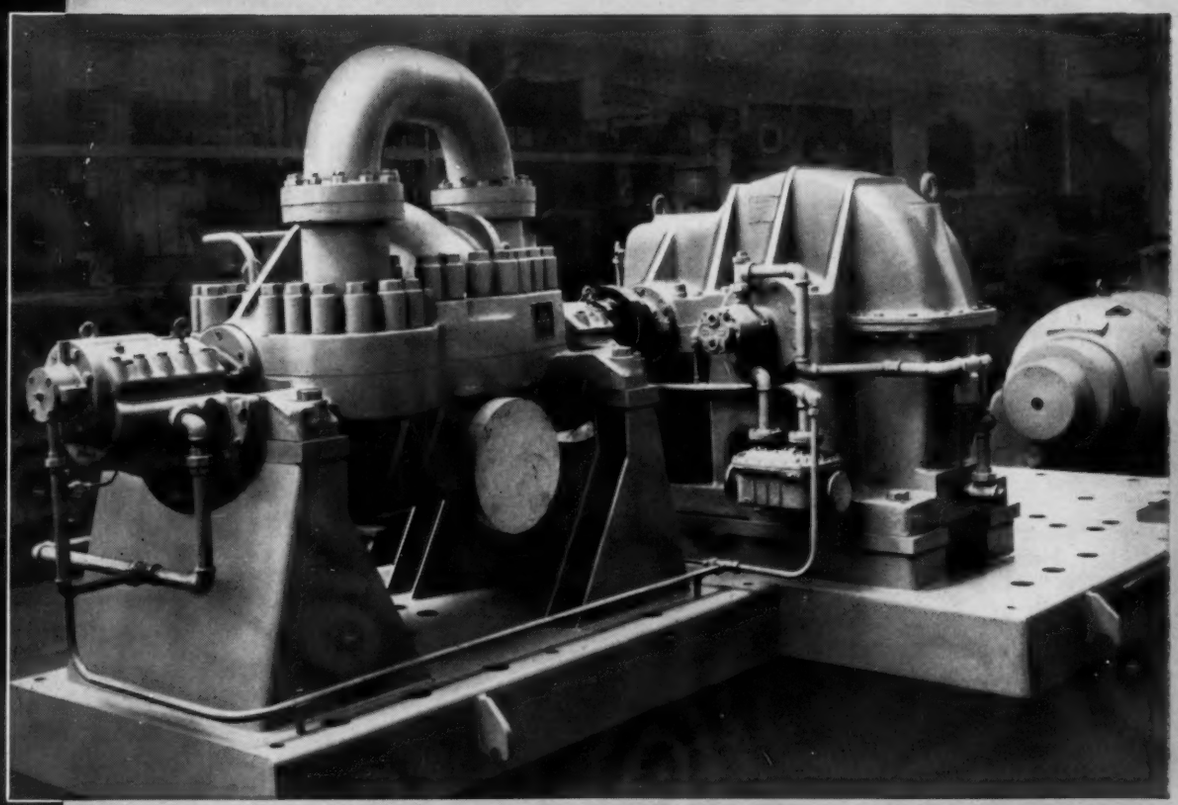


descaling at Lukens Steel

Latest successful technique of high-pressure descaling is now being performed in this modern steelmaking facility designed by Mesta Machine Co.

The initial high-pressure descaling operation uses De Laval split-case multi-stage pumps as shown in the photograph below. Each pump supplies cold water at 1000 gpm and 1600 psig. Electric motors rated at 1750 hp drive the pumps through speed increasers which raise the speed from 1200 rpm to 4250 rpm.

De Laval pumps also serve Lukens on a 1200 psig descaling system in another section of the Coatesville, Pa. mill.



One of several arrangements available for descaling service at pressures of 1000-1200-1600 psig and capacities to 2200 gpm.

DE LAVAL *Steam Turbine Company*

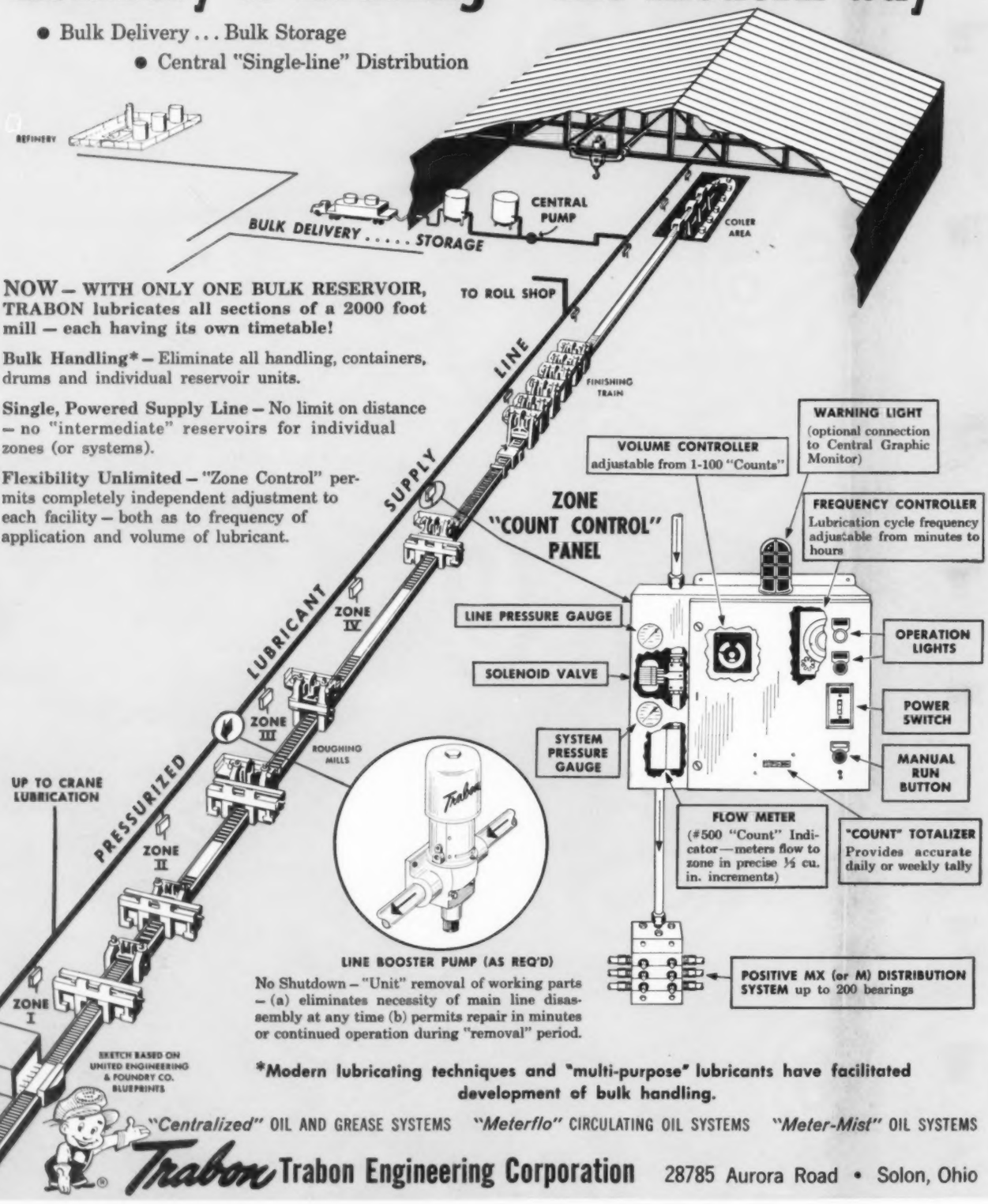
870 NOTTINGHAM WAY, TRENTON 2, NEW JERSEY

TRABON®

CENTRALIZED LUBRICATING SYSTEMS

Refinery to bearing—the modern way

- Bulk Delivery . . . Bulk Storage
- Central "Single-line" Distribution


REFINERY
BULK DELIVERY . . . . . STORAGE
CENTRAL PUMP
COILER AREA
TO ROLL SHOP
SUPPLY LINE
FINISHING TRAIN
LUBRICANT
PRESSURIZED
ZONE I
ZONE II
ZONE III
ZONE IV
ROUGHING MILLS
UP TO CRANE LUBRICATION
SKETCH BASED ON UNITED ENGINEERING & FOUNDRY CO. BLUEPRINTS
ZONE "COUNT CONTROL" PANEL
WARNING LIGHT (optional connection to Central Graphic Monitor)
VOLUME CONTROLLER adjustable from 1-100 "Counts"
FREQUENCY CONTROLLER Lubrication cycle frequency adjustable from minutes to hours
LINE PRESSURE GAUGE
SOLENOID VALVE
SYSTEM PRESSURE GAUGE
OPERATION LIGHTS
POWER SWITCH
MANUAL RUN BUTTON
FLOW METER (#500 "Count" Indicator—meters flow to zone in precise ½ cu. in. increments)
"COUNT" TOTALIZER Provides accurate daily or weekly tally
POSITIVE MX (or M) DISTRIBUTION SYSTEM up to 200 bearings
LINE BOOSTER PUMP (AS REQ'D)

NOW – WITH ONLY ONE BULK RESERVOIR, TRABON lubricates all sections of a 2000 foot mill – each having its own timetable!

Bulk Handling* – Eliminate all handling, containers, drums and individual reservoir units.

Single, Powered Supply Line – No limit on distance – no "intermediate" reservoirs for individual zones (or systems).

Flexibility Unlimited – "Zone Control" permits completely independent adjustment to each facility – both as to frequency of application and volume of lubricant.

No Shutdown – "Unit" removal of working parts – (a) eliminates necessity of main line disassembly at any time (b) permits repair in minutes or continued operation during "removal" period.

***Modern lubricating techniques and "multi-purpose" lubricants have facilitated development of bulk handling.**

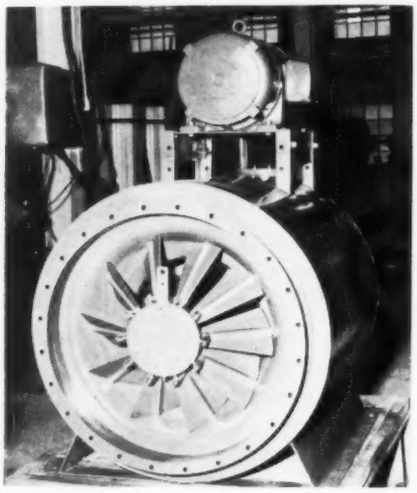
"Centralized" OIL AND GREASE SYSTEMS *"Meterflo"* CIRCULATING OIL SYSTEMS *"Meter-Mist"* OIL SYSTEMS

Trabon Engineering Corporation 28785 Aurora Road • Solon, Ohio

Equipment News...

CENTRIFUGAL FAN

△ Westinghouse Electric Corp. has announced the introduction of a new straight-line flow centrifugal fan, produced by the Sturtevant Division. This new development will make it possible for architects, consulting engineers, plant engineers and building designers to make air



conditioning and air handling fan installations in less then one-half the space previously required.

The new unit, trade-marked "Centriline," combines the advantages of Airfoil-bladed centrifugal fan performance with the important space-saving features of straight-line air flow.

The new fan is expected to open up new design possibilities by providing the opportunity to utilize "small" areas in both commercial and industrial buildings that were formerly considered "waste" space. For specifier and installer this will mean cost reduction and simplicity of erection. The compact design makes it possible to hang the fans from the ceiling, mount them on the wall or stack them one above the other, saving valuable floor space.

The physical size of the fan itself ranges up to 50 per cent less than conventional scroll-type units. This has been achieved by shaping the housing to provide "straight-through" air flow rather than the conventional right-angle flow.

While the exterior shape of the fan resembles that of an axial fan, it is definitely of the centrifugal type. The high efficiency of the fan is achieved primarily through the use of the Airfoil-bladed centrifugal wheel which enables the air to follow the blade contours closely and prevent noise-producing turbulence on the upper blade surfaces. Newly-developed aerodynamic conversion vanes also play an important part in the minimizing of noise, an important element for human comfort in modern-day installations.

The new fan is rated according to the same Air Moving and Conditioning Association (AMCA) classifications as conventional scroll-shaped centrifugal fans. The "Centriline" fan is available in six sizes, with airfoil wheels from 27 to 44½ in. in diameter, all of unobstructed design with no intermediate rings or stay rods to interfere with quiet streamline air flow.

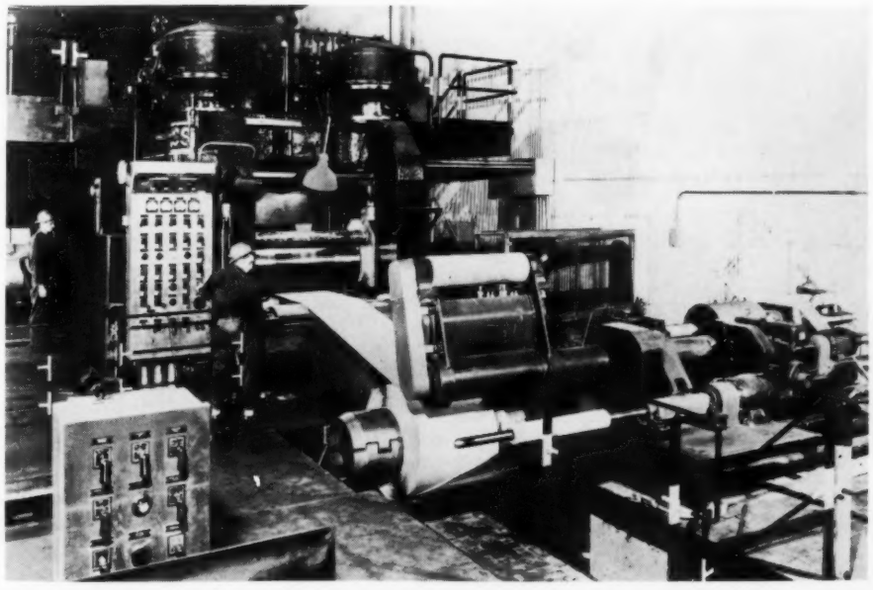
Installation is made simpler because inlet and outlet dimensions are the same, and one size duct may be used. Performance and sound levels closely duplicate those of the conventional scroll-shaped Airfoil-bladed centrifugal fans of the same wheel diameter.

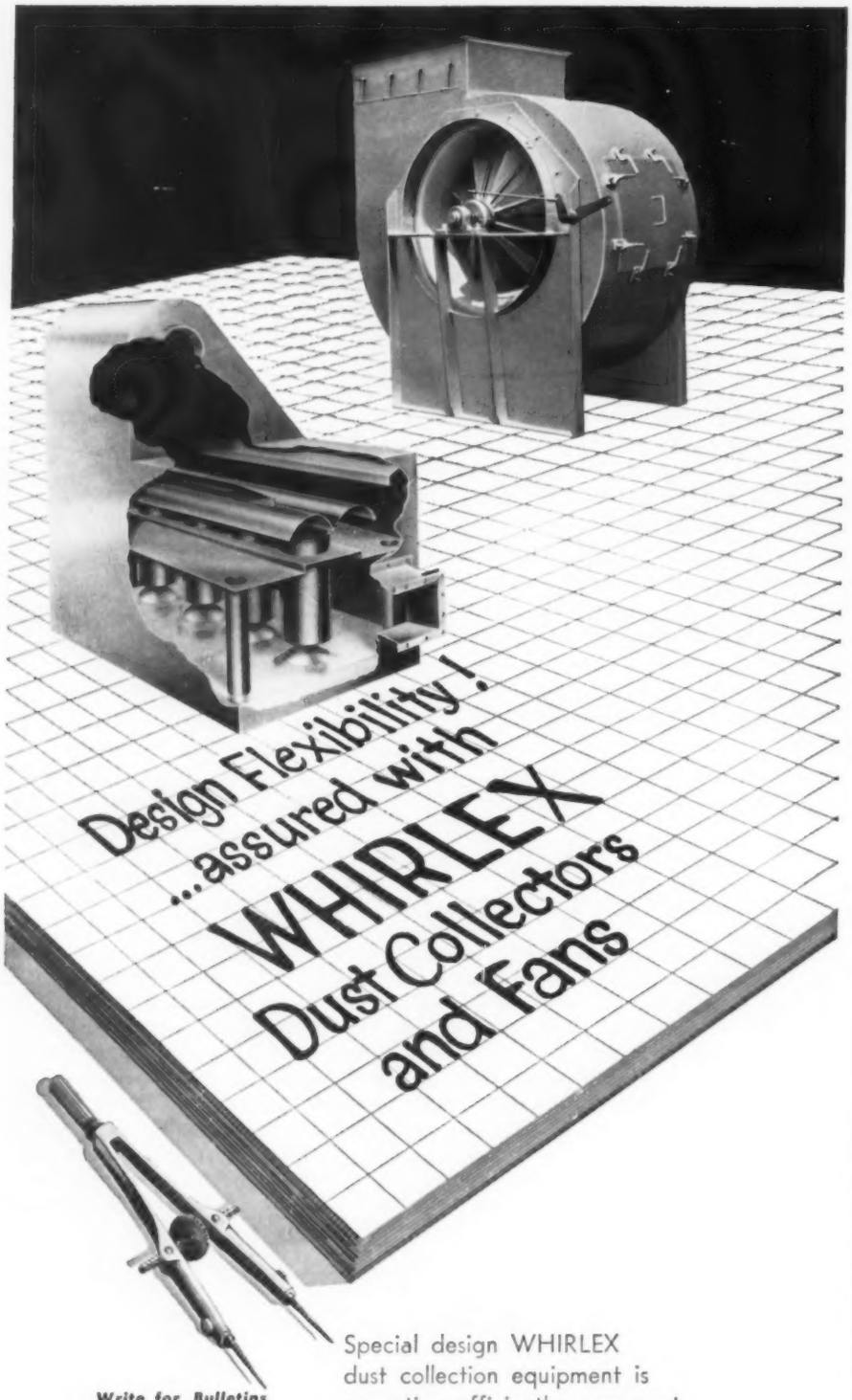
In effect, the new fan makes it a relatively easy matter for more supply and exhaust systems to be installed in the same space, thereby reducing the number of equipment rooms required. In turn, because of the important savings in space, equipment rooms can be smaller with a consequent saving in construction investment. The space saved can also be evaluated in terms

▲

NEW GARY TEMPER MILLS IN OPERATION

A new temper mill, built by E. W. Bliss Co.'s Rolling Mill Division, has recently gone into operation in the Stainless Department at Gary Sheet & Tin Division of U. S. Steel Corp. Designed to handle coiled strip up to approximately 50 in. wide and as narrow as 25 in., it is used to temper stainless gages in the range between 0.016 in. and 0.140 in. Another Bliss temper mill serves as a key unit in Gary Sheet & Tin's new continuous pickling line. Hot rolled coils are welded together and passed through the new mill which is located prior to the pickling section. The temper mill will break the oxide thus accelerating the pickling operation. Strip handled ranges up to 60 in. in width in thicknesses between 0.059 in. and 0.187 in. The mill is equipped with entry tension bridle and delivery tension bridle to maintain the right tension on the strip during the pass through the mill.





Write for Bulletins
FD-11 & WC-100

Special design WHIRLEX dust collection equipment is operating efficiently over most of the world. Special designs for special applications are a specialty with WHIRLEX!

FLY ASH ARRESTOR
CORPORATION
205 North 1st Street / Birmingham, Alabama
1355 Market Street, San Francisco 3, Calif.
420 Lexington Avenue, New York 17, N.Y.

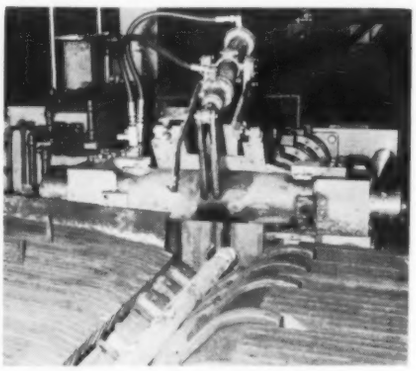
Bag Collectors — Mechanical Collectors — Wet Collectors
Induced Draft Fans — Forced Draft Fans — Exhaust Fans
Self Supporting Stacks — Duct Work

of greater utilization and additional rentable income.

BILLET CENTERING UNIT

△ The Ohio Seamless Tube Division of Copperweld Steel Co., recently installed a unique hydraulic billet centering machine as part of their modernization and expansion program. The unit was designed and built by the Lombard Corp.

The accurate center hole placed in the billet by this machine is reported to greatly improve the rotary piercing and subsequent mill operations. Amount of shell crop loss has been appreciably decreased due to the excellent concentricity of the starting end of the shell now produced on the piercing mill. Increased depth of center hole also facilitates the ease of entering the billet into the rotary piercing rolls.



The centering unit is unique in that only the work end of the billet is gripped while the hole is being formed. Slenderness or the length of billet has no bearing on this operation. After the billet has been pushed between the gripping jaws a dual purpose hydraulic cylinder automatically closes the jaws and moves the centering tool into the billet. Billet is ejected as the tool and gripping jaws are retracted.

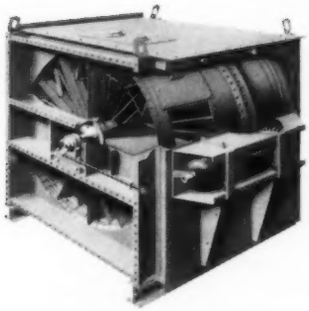
The billet centering machine can center up to 7 in. diameter alloy billets at the rate of up to 5 per min. Inasmuch as the mechanical and hydraulic components are self contained they can be adapted for use with existing tables without major modification to same. Complete installation can be accomplished over a weekend.

MILL BRAKE

△ Cutler-Hammer has developed a 30 in. 505 mill brake to satisfy the heavier requirements of frame 620, 622 and 624 mill motors.

NEW...FOR STEEL PROCESSING FURNACES

continuous regenerative Air Preheaters



THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N. Y.

1. The Ljungstrom® Metallic Rotary Regenerative Air Preheater has had widespread use in this country, in the industrial and utility fields since 1925. Over 3500 units are now in operation. These include those of high temperature alloy design for refinery installations.

2. Now we are prepared to apply our regenerator to steel plant furnaces, particularly to proposed reheat furnaces and soaking pits. Because of its compactness and layout flexibility, the Ljungstrom also might well be considered for up-grading existing furnace capacities by raising preheated combustion air temperatures.

3. For your study and analysis, we would like to offer our services in selecting a suitable preheater and submitting its performance and cost for any given application. To accomplish this, we request that you send us the following data:

1. Type Furnace_____

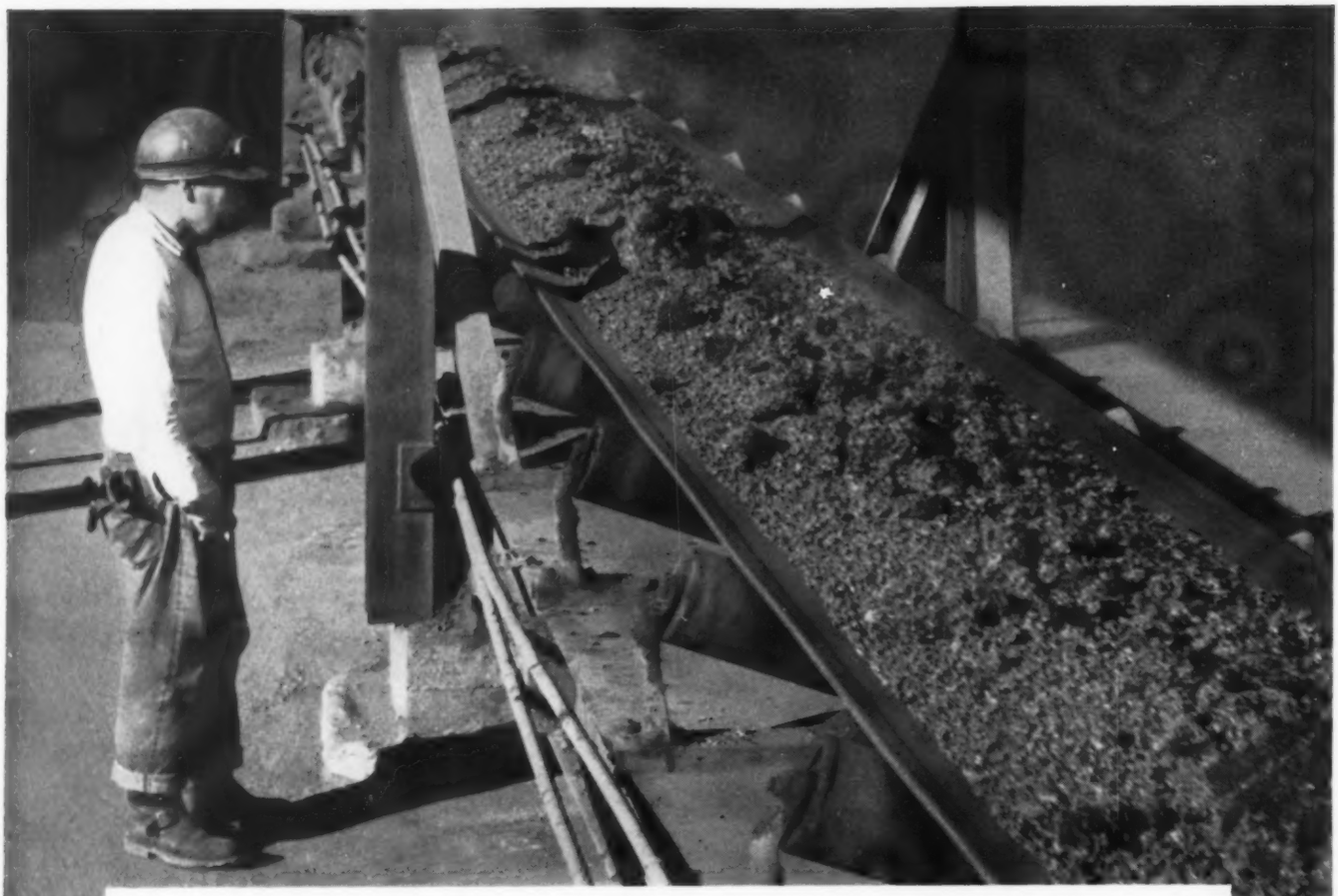
2. Fuel Type_____ Heating Value_____ Cost_____

3. Fuel Rate . . . BTU/HR_____

4. Ambient air temperature . . . °F_____

5. Flue gas temperature . . . °F_____

6. Desired combustion air temperature . . . °F_____

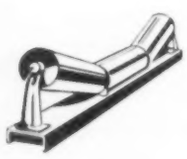


Here's How To Handle Hot Sinter Problems!

Heat, abrasive dusts, and continuous heavy loading pose special problems in sinter plant operation. Specially engineered Hewitt-Robins equipment, such as this conveyor moving hot sinter to the blast furnaces of a Western steel mill, provides dependable sinter plant operation month after month. Other H-R sinter plant equipment includes:

- Belt Conveyors—Resist abrasion, high temperatures, and withstand the impact and tension of heavy loads and long runs.
- Jones Drives for Feeder Tables—Provide dependable power transmission where continuity of operation affects the entire plant.
- Hot Sinter Screens—Efficiently screen fines with minimum degradation, resist exposure to heat, and give long life in handling abrasive sinter.
- Belt Cleaners—Eliminate a major maintenance job; improve idler and pulley life by keeping conveyor belts clean.

The rugged efficiency of H-R sinter plant equipment is found in all H-R equipment for the steel industry. For full details consult your H-R representative, or write Hewitt-Robins, Stamford, Connecticut. Ask for Bulletin 10-50.



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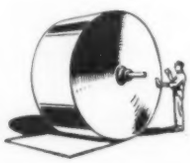
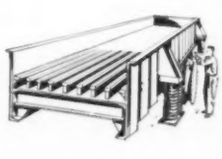


CONVEYOR BELTING

SPEED REDUCERS



VIBRATING EQUIPMENT

HEWITT-ROBINS

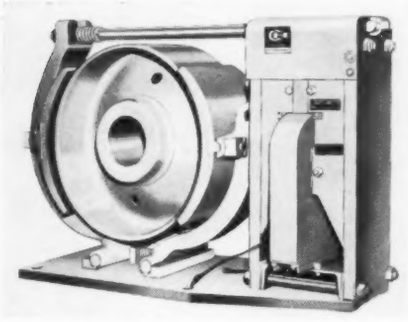
THE NAME THAT MEANS EVERYTHING IN BULK MATERIALS HANDLING SYSTEMS...

CONVEYOR BELTING AND IDLERS • INDUSTRIAL HOSE • VIBRATING FEEDERS, SCREENS & SHAKEOUTS • POWER TRANSMISSION EQUIPMENT

The new brake is rated at 9000 lb ft ½ hour series wound or one hour shunt wound, 6750 lb ft continuous duty shunt wound and 6000 lb ft one hour series wound.

Other brakes in the 505 line are 8, 10, 13, 16, 19 and 23 in. The same simplicity of design that characterizes these brakes are found in the 30 in. No pivot pins are used in the base or shoe levers and the pull rod over the wheel operates the outer shoe lever without the use of additional linkages. Individual shoe travel adjustments are provided and feeler gages built into the brake permit checking the shoe travel adjustment without energizing the brake.

Because of the high torque rating of the brake and consequent high forces that would be involved in the



use of a single torque spring, two torque springs are employed—and these are located near the top of the brake magnet. Thus, the torque and shoe travel adjustments are all located at the top of the brake where they are readily accessible.

The brake coil is encapsulated in a weatherproof stainless steel case with flexible leads for external connection. The high speed operation that is desired is obtained by the use of fabricated laminated magnet armatures together with the very short stroke that is inherent in the 505 brake design.

DRIVE SYSTEMS

△ Reliance Electric and Engineering Co. has introduced its new special purpose digital controlled drive systems.

The new systems offer precise accuracies, rugged modular construction, built-in test equipment, and full system responsibility. On cut-to-length lines, for instance, the new systems are capable of precise cutting to any desired length, calibrated in increments as fine as 1/64 of an inch.

The principal advantage of a digital control system is its extreme accuracy. When accuracy requirements are more exacting than 1/10 of 1 per cent, and where system component drift might cause a problem, digital techniques can offer an excellent answer, since they provide no-drift accuracy.

Available in rugged NEMA 1 cabinets and enclosures, the equipment is described as being "all-environment" in application. The units will operate perfectly, right on the plant floor; there's no need to keep the equipment in separate air-conditioned rooms as was necessary with computer-type digital equipment.

The systems are all built to meet the toughest industrial usage.

Each digital system is custom-tailored to specific customer needs. The equipment is specifically designed for the individual application. This policy offers the advantage of a complete system designed and built to do a specific job in the most productive and economical manner.

(*Please turn to page 267*)

How to cut mill downtime due to bearing failures...

use A·B·K* bearings

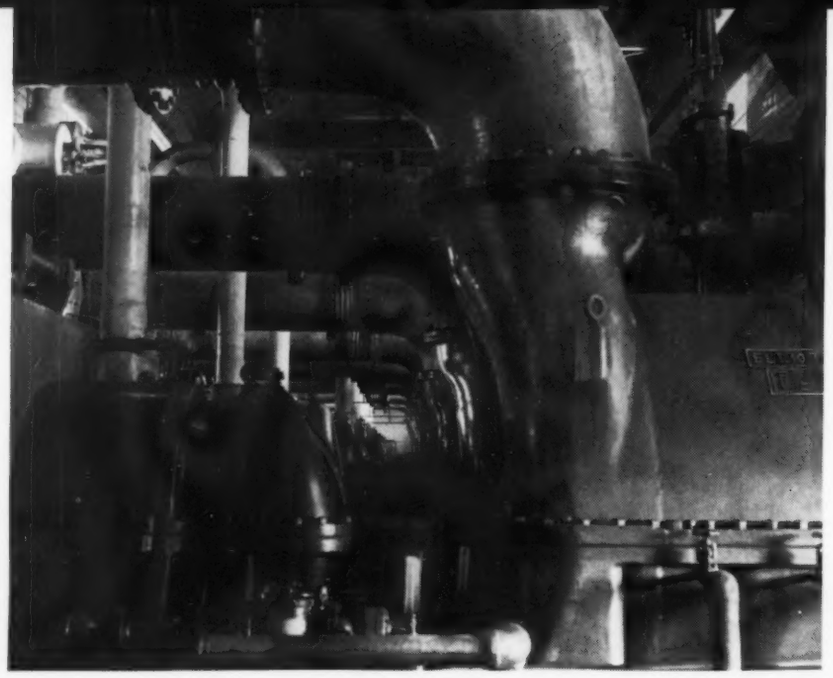
Roll neck and slipper bearings made of A-B-K material often outwear metal bearings many times. Their ability to cushion impact loads without peening, scoring or heat-checking protects roller necks, housings and chucks. Simplicity of design and light weight speed installation. Can be lubricated with grease, oil or water *alone*. Ask our engineers to help you solve your specific problems.

- Wear longer
- Won't score or heat check
- Light in weight
- Cut lubricant costs
- Save power

A·B·K
LAMINATED
PHENOLIC BEARINGS

*A registered trade-mark of American Brake Shoe Company in the United States and of Joseph Robb & Company, Limited, in Canada.

AMERICAN Brake Shoe COMPANY
AMERICAN BRAKEBLOK DIVISION
P. O. BOX 21, BIRMINGHAM, MICHIGAN



At Weirton Steel Company, eight Elliott compressors (photo right) serve a battery of 253 coke ovens. Four are exhausters rated at 24,500 inlet cfm, and four are boosters rated at 25,000 inlet cfm. All are driven by Elliott turbines.

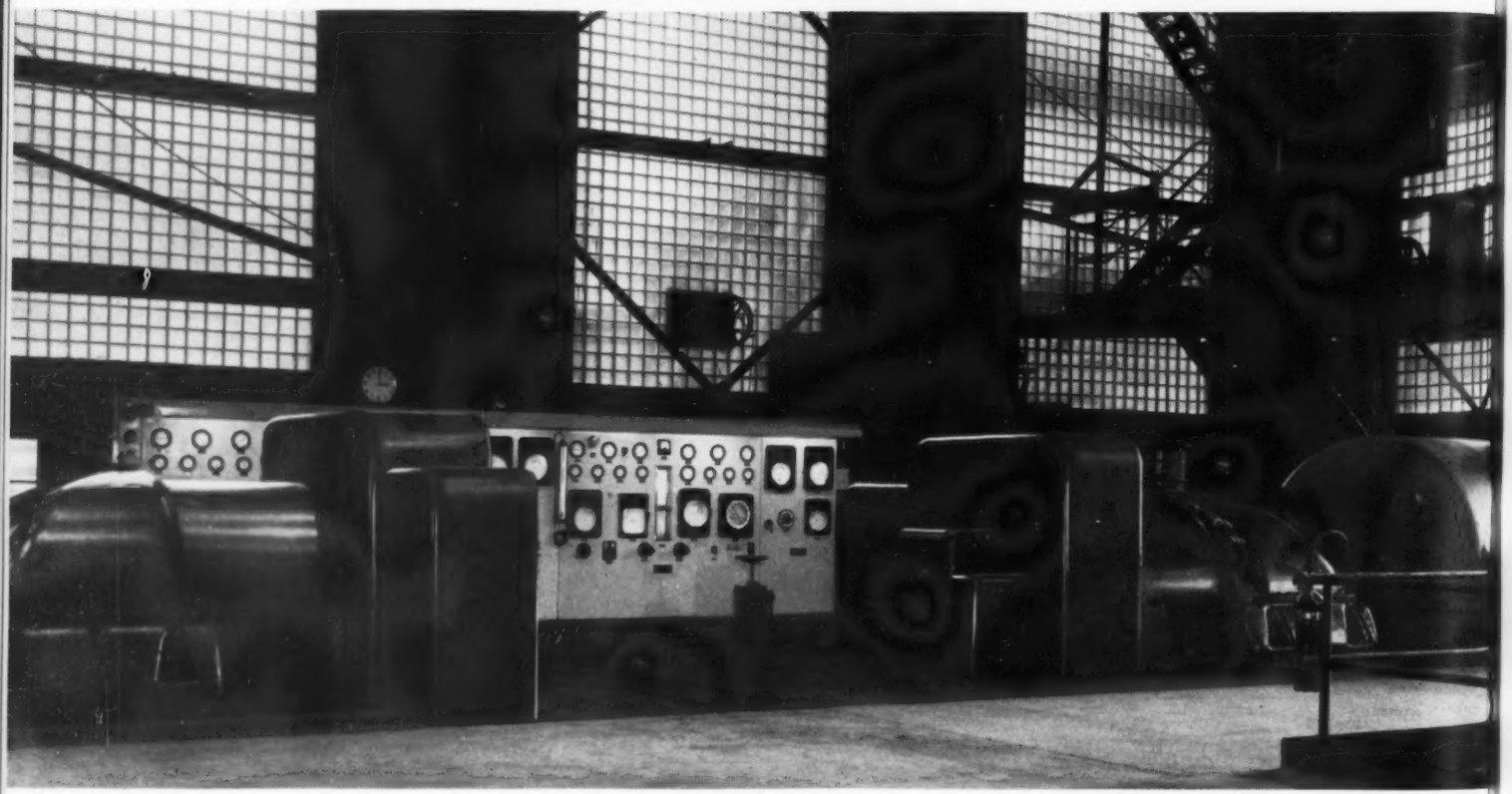


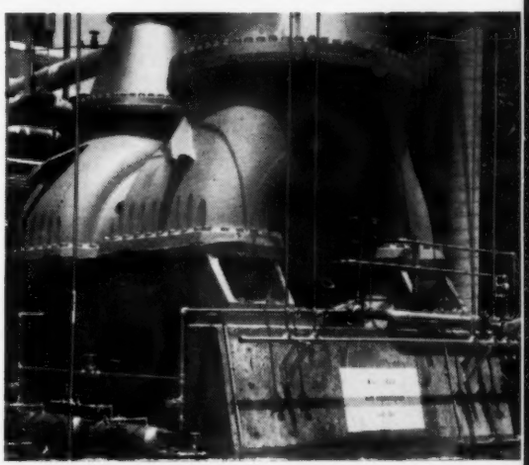
Photo above shows duplicate Elliott blast furnace compressors. Each is rated at 99,600 inlet cfm, and is driven by an 11,800-hp Elliott turbine.

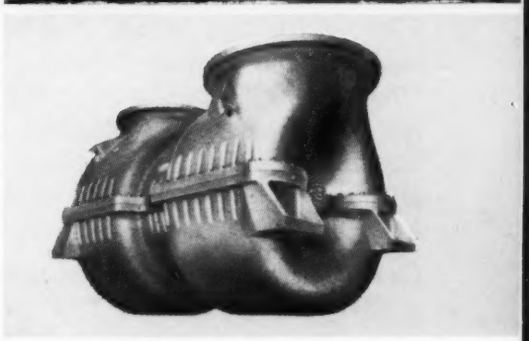
At the right are shown two of three Elliott centrifugal air compressors operating in a single blast furnace plant. All three units—driven by Elliott turbines—are rated 90,000 scfm at 30 psig air discharge.

Engineered and built for Blast Furnace and Coke Oven Service . . .

ELLIOTT CENTRIFUGAL AND AXIAL COMPRESSORS

Extensive experience in the design and application of centrifugal compressors is reflected in the excellent performance of Elliott machines for blast furnace and coke oven service. Since 1926, Elliott has made industrial compressors, and many of these are furnishing air for blast furnaces, and serving as boosters and exhausters for coke ovens. Typical examples are illustrated on these pages.





Multi-stage compressors of the axial flow type are designed and engineered specifically to serve the needs of the iron and steel industry for the handling of air or gas mixtures in large volume flow operation. Frame sizes are rated up to approximately 600,000 cubic feet per minute when operating on air.

COORDINATED ELLIOTT DRIVERS

Elliott is a leading manufacturer of both steam turbines and electric motors, of all types and ratings necessary to provide driving power for compressor units. Consequently, we are in position to recommend and furnish the type of drive best suited for each application. Both units being engineered and built by Elliott is a decided "plus" because it means unified responsibility, unified service.

FOR AIR OR GASES

Elliott integrated compressor units are available for handling all types of compressible fluids, within the pressure and flow limits of the machines. Where corrosive gases are handled, special materials are employed in vulnerable spots; where high pressures are needed, extra heavy construction is used; where leakage must be prevented, special shaft seals are available; where high temperatures must be avoided, provision is made for cooling.

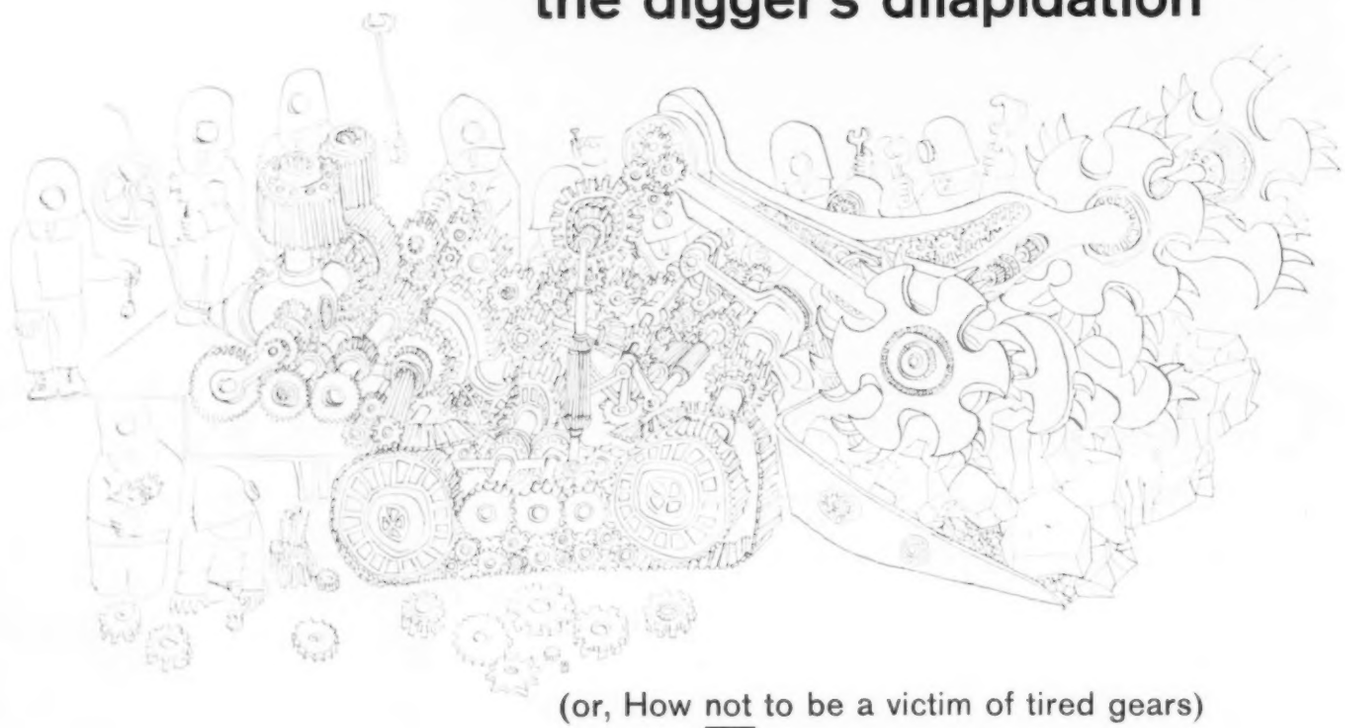
48 STANDARD FRAME SIZES

A total of 48 frame sizes permits accurate compressor application over the entire range of 500 cfm to 600,000 cfm. Pressures and speeds can be selected to meet the characteristics of the application, and the gas to be handled. For further information, write Compressor Department, Jeannette, Pa.

ELLIOTT THE MOST COMPLETE LINE OF **INTEGRATED COMPRESSOR & DRIVER UNITS** 500 cfm to 600,000 cfm

ELLIOTT Company
Jeannette, Penna.

the digger's dilapidation



(or, How not to be a victim of tired gears)

She was a beauty when they brought her in. Shiny paint. Ferocious teeth that could chew out a whopping 5 tons of coal per minute. A drive that looked like it could rout out a vein from here to Medicine Hat, Montana, and back. At least that's the way it *looked*. Then one day fatigue set in. The old girl had tired gears. There were sounds like skis falling down stairs, a crack of doom and, wham, she stopped right in the middle of a bite. Busted gear.

Gear failure costs money, especially in terms of downtime and lost production. That's why it is essential to use *quality* alloy steel for gears, bearings, shafts and other highly stressed parts. Only the best is good enough when any failure is costly. The care and precision in making USS Alloy Gear Steels are for one purpose: prevention of failure. USS Alloy Gear Steels deliver dimensional stability. They come in a wide range of mechanical properties and processing capabilities.

Be sure to specify USS Alloy Gear Steels for *any* of your gear requirements. Carburizing steels for toughness, shock and wear resistance; through-hardening steels for heavy loads at slow and medium speeds; cyaniding and nitriding steels for wear.

For more information and prompt metallurgical assistance, call our nearest sales office or United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS is a registered trademark

The Lee-Norse Company's continuous coal miner will never be a victim of tired gears. Alloy steels such as 3310, 4815, 4820, 4320, 4340 and 8620 give its gears, pinions and shafts superb toughness and resistance to impact and wear. These cutter head drive gears are made of 4820, 4320 and 4817 alloy steels.

USS

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

United States Steel

This mark tells you a product is made of modern, dependable Steel.

(*Continued from page 263*)

Modular construction of the digital control systems, coupled with printed circuit boards and Sealpak (complete special-purpose electronic circuits embedded in a solid block of resilient plastic) construction provide long, trouble-free life. Individual circuits are built into their own modules for easy check-out and replacement.

All Reliance digital controlled drive systems are provided with built-in test equipment for fast system checks. No complicated test procedures are required. Readily accessible test fixtures allow easy check-out of circuits on the spot; plug-in modules allow simple, no-fuss replacement.

Channel wiring is used throughout the systems, except in sensitive circuitry where direct wiring is required. Power and signal leads are carried in separate channels to insure interference-free operation. Flexible wiring, connected without sharp bends, prevents vibration damage while it materially lengthens equipment life.

Typical applications of the digital control systems are cut-to-length lines, classifier lines, test stands and press feeders.

CONTACTORS—STARTERS

△ Size 00 magnetic contactors and starters for low-horsepower light duty applications have been added to General Electric Co.'s 100 line of motor starters.

Designed specifically for controlling conveyors, small pumps and fans, the size 00 starter offers about an 18 per cent price saving over the size 0 starter which might have been used previously for such applications.

The new starters and contactors incorporate all the features of the 100 line which includes easier and faster installation, less maintenance, production reliability, and straight-out-the-front disassembly. In addition, the new units, retain the family appearance of size 0, 1 and 2 starters and contactors.

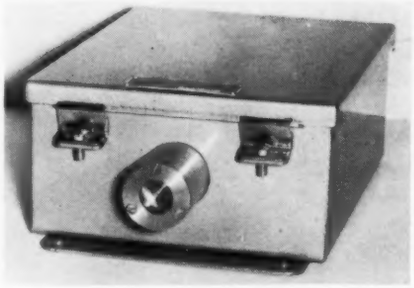
Faster installation is made possible because of straight through wiring, clearly identified pressure-type terminals, keyhole slots and convenient knockouts for easy conduit connection.

Maintenance is less time consuming because of snap-slide disassembly which permits inspection from the front of the starters without tools in less than one minute.

Production reliability is increased by vertically slanted contacts, with horizontal action, to reduce contact contamination from dirt and dust. Wedge-action contact design with low armature mass virtually eliminates contact bounce. The "start wire" in the long-life, strong-box coil is "Mylar" insulated for fewer coil failures.

The straight-out-the-front disassembly means inspection and maintenance can be performed without extra space being left around the starter. Pushbutton and selector switch kits for field or factory in-

DETECTOR-RELAY



This detector/relay combination based on infrared rays can sense the presence of any moving hot object and will start, stop or adjust relay controlled equipment associated with the process. The unit can be used at distances up to 20 ft, and was originally designed for use in conjunction with automatic rolling mill control systems to detect the position of hot strip. The unique feature is that it responds only to *moving* hot objects and does not pick up a hot backgound. Some uses would be to close furnace doors, to start and stop water sprays, coilers, etc., to reverse rolls, and to count number and frequency of operations. The equipment is built by The Electron-Machine Corp. The temperature of the object affects the speed at which it must move and the distance of the detector from the object. For example, at a speed of 20 ft per minute and a distance of 5 ft, the temperature must be about 1300 F. However, in this case as the moving object speed goes up to 1200 fpm, the temperature need be no higher than 600 F. If the distance is 20 ft and the speed is 20 fpm, the temperature must be 2050 F, but at speeds of 5000 fpm temperatures as low as 800 F will operate the equipment.

For accurate control of material flow—W-C CONSTANT-FEED WEIGH-HOPPER SYSTEMS

Wherever formulating or processing operations require highly accurate, uniform flow-rate control of dry, liquid or even hard-to-handle bulk materials, W-C Constant-Feed Weigh-Hopper Systems will do the job . . . continuously, automatically, economically.

Far more accurate than volumetric systems, W-C Constant-Feed Systems achieve precise control by continuously measuring the rate of material weight loss during discharge from a hopper (or tank), and regulating that discharge to maintain a linear rate of reduction.

Using pre-engineered, unitized components, W-C can provide a Constant-Feed System custom fitted to your particular applicational demands. The cost is reasonable because the components are standard . . . whether for Simplex, Duplex or Proportioning-Type Systems.

Typical applications include: Feeding pulverized coal to oxygen mixer for steel mill furnaces.

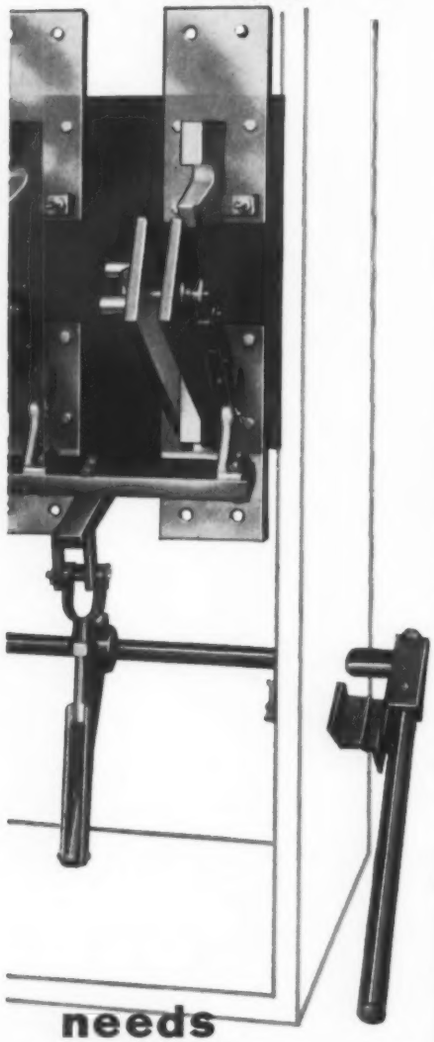
Write for new Bulletin 40

W & C **WEIGHING & CONTROLS, INC.**
Div. of CompuDyne Corp.

E. County Line Road • Hatboro 16, Pa.
S-A. 2048

RARELY

(IF EVER)



needs

MAINTENANCE

Pringle disconnect switches for high-current equipment carry as much as 50,000 amperes, continuously, with no more of a heat rise than you would get from copper bus bars bolted together. These switch blades actually are bolted together. Under a constant pressure of 600 lbs./sq. inch. Without springs. Yet, they open easily after months (or years) of closed operation. Heat, fatigue, lack of movement won't affect the operating mechanism. Constant, periodic maintenance is unnecessary.

Less complex than most high-capacity disconnect devices. Less expensive too. Available in single- or multi-pole models, front or rear connected, live front or steel enclosed. With or without high-capacity fuses. For use on crane conductor rails, transformer secondaries, or AC and DC switchboards. Wherever high-current equipment must be isolated for periodic servicing.

Write for Industrial Switch Catalog

PRINGLE

ELECTRICAL MANUFACTURING CO.

1900 NORTH SIXTH STREET
PHILADELPHIA 22, PENNA.

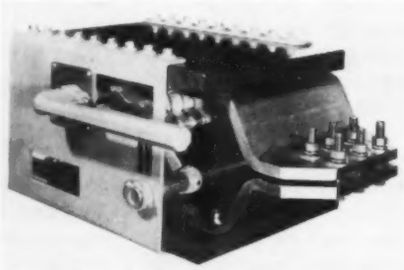
stallation give added flexibility for meeting specific applications.

Available for either 115 or 230 volts, the 00 starters and contacts are single, two- or three-phase with ratings from ⅓ to 2 hp.

DISCONNECT SWITCH

△ Delta-Star Electric Division, H. K. Porter Co., Inc. has announced a new low voltage high current disconnect switch for steel mill and heavy industrial use.

Suitable for 750 volt operation, the copper "Wedge" type switch is



available in a standard 5000 amp unit or in multiples of 5000 amp for use in gang operated applications. Both single-throw and double-throw designs are offered. A current application of this switch is in a differential tinning line where the switches are bolted directly into the buswork without other means of support.

Design features include self alining hard-drawn copper contact wedges offering good wiping action both closing and opening, positive nonfatiguing backup springs for constant high pressure, silvered contact surfaces, positive locking type operating handle, and generous copper cross sections for lower resistance. A further development is an auxiliary blade with arcing tip which closes first and opens last during switch operation.

The switch is compact, and can be fitted with such devices as auxiliary switches for indicating light circuits.

Book Reviews

"Progress in Metallurgical Technology" has been published recently by Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1, England. The book contains 147 pages, 8¾ x 5½ in., is cloth bound, and sells for 32s. 6d. net (postage extra). This book contains the four papers given at the 13th Annual

(*Please turn to page 272*)

More equipment manufacturers choose Fast's Couplings than any other gear-type coupling

Leaving other claims aside, the thing that counts in couplings is customer confidence —and industrial equipment manufacturers have made Fast's their overwhelming choice. The Fast's line is more diversified, too—in a complete range of sizes and types for shafts, from ¼" to 32" and larger.

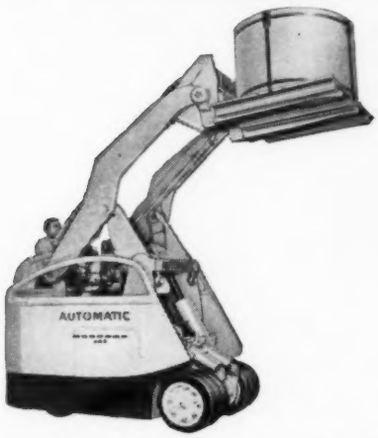
Every Fast's Coupling brings you superb engineering only the original gear-type coupling can deliver. Smooth-running units that are designed to outlast the machines they connect. Rapid service from experienced field engineers backed by outstanding stock facilities. Write today for full details on couplings to suit your needs to: KOPPERS COMPANY, INC., Fast's Coupling Dept., 110 Scott St., Baltimore 3, Maryland.

KOPPERS®

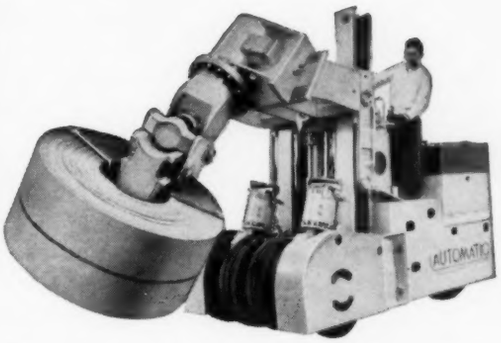
FAST'S COUPLINGS

Engineered Products Sold with Service

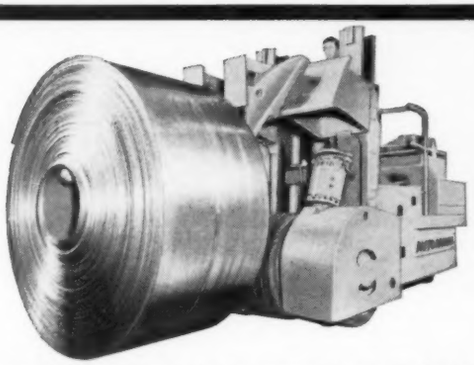
LOWEST COST WAY TO HANDLE COILED STEEL



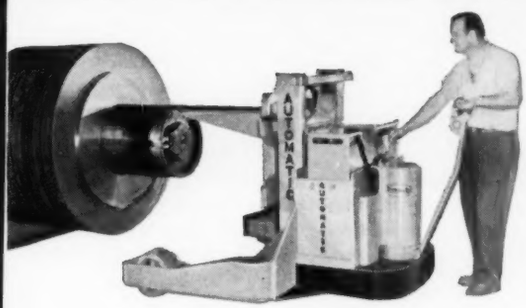
Exclusive Elbolift is most compact, most maneuverable heavy duty truck in its capacity range of 12,000 to 25,000 lbs. Loads coils in boxcars, positions coils on flat-bed trucks in one operation, stacks 120" high.



It's a mobile coil up-ender! Unique wrist-action rotating up-ender and clamp picks up horizontal or vertical coils and rotates them to opposite position. Clamp prevents telescoping. Capacity to 60,000 lbs.



Heavy Duty Giant is available in capacities from 20,000 to 100,000 lbs. This capacity range permits strip mills to roll larger, heavier coils to boost production and lower costs.



Heavy Duty Transporter with coil handling ram is ideal for jobs which involve close quarters, short distances, and intermittent use. Capacity to 20,000 lbs. in pallet, platform, fork or ram models.

AUTOMATIC

HEAVY DUTY TRUCKS

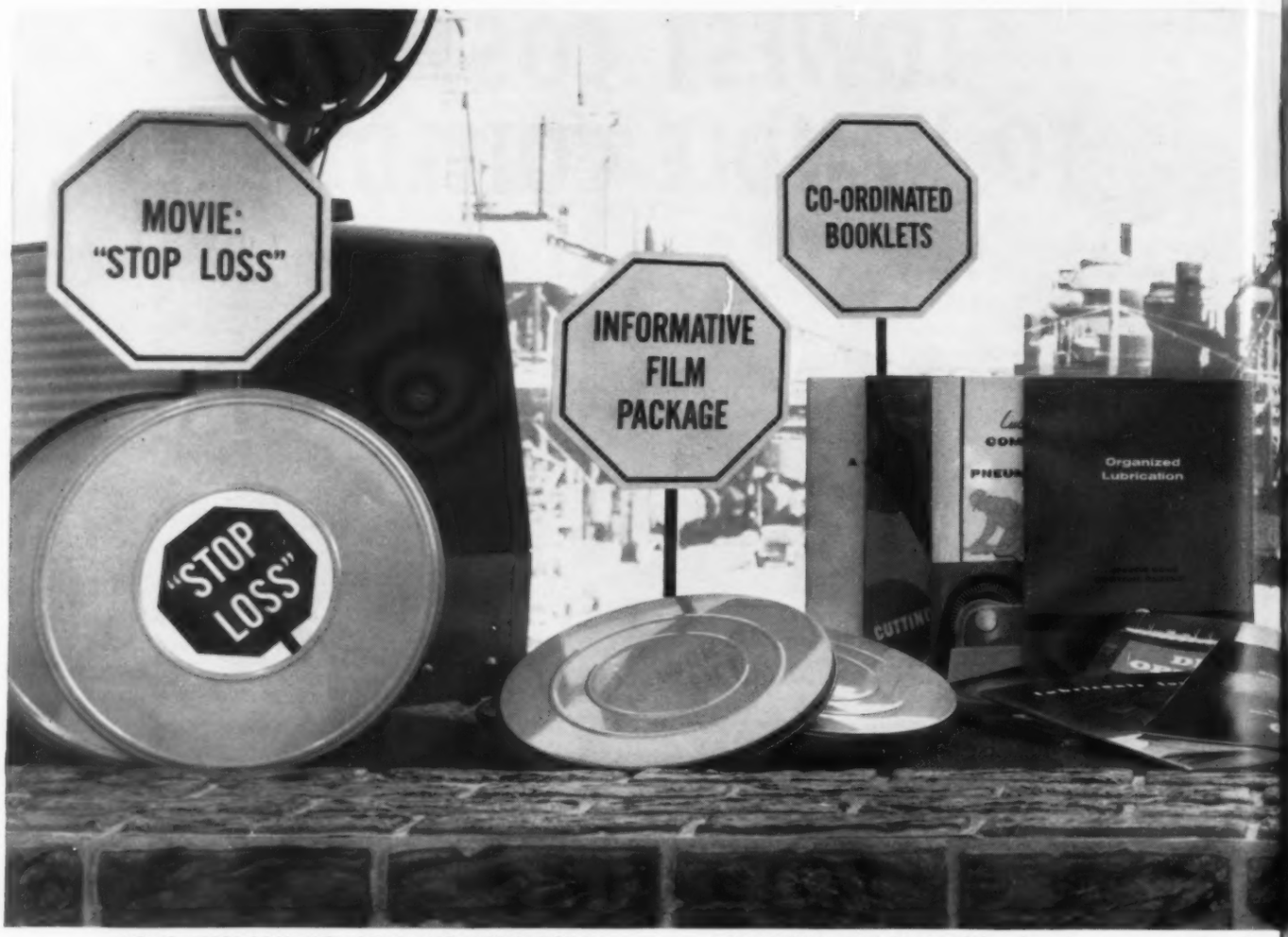
IN CAPACITIES TO 100,000 LBS.

No other handling equipment gives you the mobility and flexibility of heavy duty lift trucks. You can handle loads anywhere in the plant—even into boxcars—without transferring the load to other equipment. With a lift truck, handling usually is a one-man job. What's more, lift trucks adapt easily to production changes.

Automatic brings you all of these advantages with trucks designed specifically to handle coiled steel weighing up to 100,000 lbs. There are models with hydraulically-adjustable rams, fork lift models for palletized coils, high lift coil stackers and walkie models for intermittent use over short distances. A new bulletin tells how heavy trucks can be profitably used in the steel industry.

Write for your free copy of Heavy Duty Trucks Facts and Factors today.

AUTOMATIC **AUTOMATIC TRANSPORTATION COMPANY**
Division of The Yale & Towne Manufacturing Co.
47 W. 87th Street, Dept. TO, Chicago 20, Illinois



MOVIE: "STOP LOSS WITH ORGANIZED LUBRICATION," a new 20-minute color-and-sound film created to show the opportunities for cost control through Organized Lubrication.

EDUCATIONAL FILM PACKAGE for plant departments consists of movies on greases, hydraulic oils, cutting oils, etc., that may be selected after seeing the "Stop Loss" film.

HERE ARE THE TOOLS THAT CAN HELP YOU

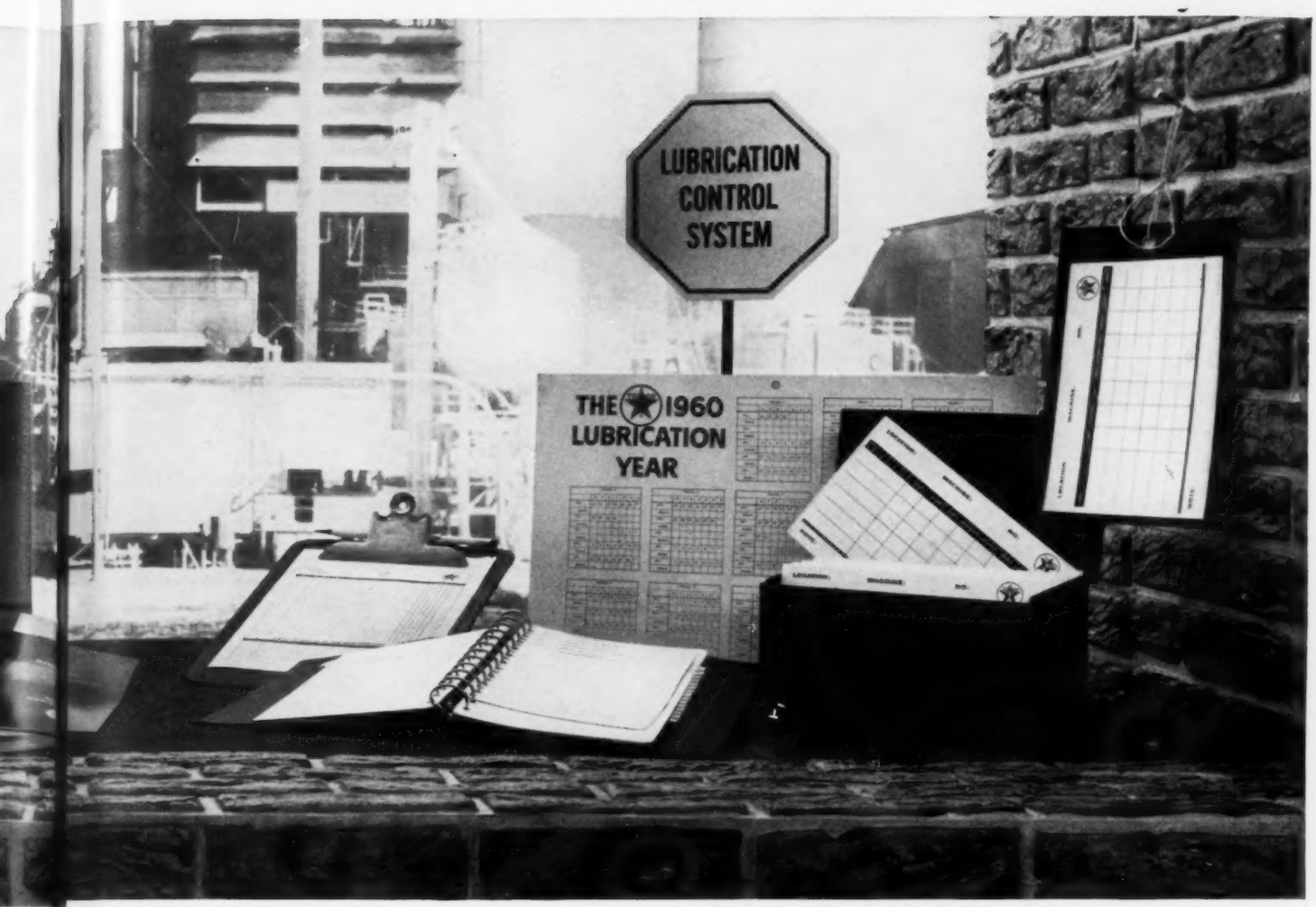
INCREASE YOUR NET PROFITS

Texaco's new "Stop Loss" program is designed to cut maintenance costs by modernizing lubrication practices. If yours is an average plant, the results can add 4 per cent to your net profit.

Even if your plant is an efficient operation, it is still virtually certain that there is an opportunity for cost control you are overlooking—either partially or completely. Here's what the Small Business Administration says in a recent publication:

Suppose there is an average plant, which sells $1,000,000 worth of goods per year. The net profit of this average company would be $73,400 and the maintenance cost would be $29,900. Now, suppose that by *better lubrication*, maintenance costs are reduced 10%, or $2990, *the $2990 will go directly into profit*—an increase of 4%.

A Texaco "Stop Loss" Program is designed for you. Texaco has developed a program specifically designed to help cut your maintenance costs via better lubrication practices. It will help you increase machine life, minimize downtime, reduce lube inventory, even cut purchasing costs. And the savings you make go directly into profits.



CO-ORDINATED BOOKLETS on the film subjects and others can be used as guides in specific areas.

TEXACO LUBRICATION CONTROL SYSTEM takes the guesswork out of your lubrication scheduling. It costs almost nothing to install, yet can add thousands of dollars a year to profits.

BY AS MUCH AS 4 PER CENT!

Can your plant pass this test? If the answer is "no" to any of the following questions, it is almost certain that a Texaco "Stop Loss" Program can improve your profit picture.

1. Is there a central source of responsibility in your plant for *all* lubrication? Yes ☐ No ☐
2. Can your machine operators devote all their time to production without worrying about lubrication? Yes ☐ No ☐
3. Is there any system for making sure that equipment gets lubricated in the right spots at the right time? Yes ☐ No ☐
4. Have you had a lubrication study made to eliminate costly duplication of lubricants? Yes ☐ No ☐
5. Are your oilers qualified men with knowledge of mechanisms lubricated? Yes ☐ No ☐

See for yourself how "Stop Loss" works! Texaco has just released a new color-and-sound movie to dramatize the benefits of good lubrication practices. It's called "Stop Loss through Organized Lubrication" and we think it would be valuable to you to see it. For a showing in your plant soon, mail in the coupon today!

Texaco Inc., 135 East 42nd Street, New York 17, N. Y.

MAKE YOUR RESERVATION TODAY!

TEXACO INC., Dept. IS-161
135 East 42nd Street
New York 17, New York

I would like to see "Stop Loss through Organized Lubrication." Please call to arrange a showing in my plant.

Name_____ Title_____

Firm_____

Address_____

City_____ Zone____ State_____

TEXACO

VALUED FOR THE

Long Haul

TM alloy slings

"Stamina for the long haul!" That's the frequent comment on the performance of TM Alloy Sling Chains in steel mills, foundries, forge shops, mines and countless other industries.

Bulletin 14A—packed with facts and specifications—gives you many reasons why TM Alloy Chain is valued by so many. Call your industrial distributor, steel warehouse, hardware wholesaler, or write today for your copy.

Taylor Made CHAIN SINCE 1873

Prompt repairs on alloy slings in both plants.

S. G. TAYLOR CHAIN CO., Inc.
Plants: Hammond, Indiana
3505 Smallman St., Pittsburgh, Pa.

(*Continued from page 268*)

Refresher Course of the Institution of Metallurgists held at Scarborough in 1959. The first paper "Modern Development in Iron and Steel Production" by John Taylor deals with modern developments in the production of iron and steel, and discusses the revolution in steelmaking practice due to the advent of tonnage oxygen. The second paper, "Extraction and Refining of Non-Ferrous Metals" by A. V. Bradshaw, outlines the various methods now in use for the extraction and refining of non-ferrous metals, and gives a detailed description of the newer processes. The third paper, "Melting of Ferrous and Non-Ferrous Metals" by A. G. Robiette, deals with the melting of ferrous and non-ferrous metals, and shows that although methods have not changed greatly, improved equipment and greater mechanization has increased efficiency and production of purer metals. The other paper, "Casting of Ferrous and Non-Ferrous Metals" by D. V. Atterton, shows how it has been possible to attain at the same time both an increased rate of production and a high level of quality. Included also are 37 diagrams and 16 pages of art plates.

"The Robertson Guide to World Screw Thread Standards" has been published recently by the W. H. A. Robertson & Co. Ltd., Lynton Works, Bedford, England. The book contains 41 pages, 6 x 9 in., is bound in heavy paper, and sells for $1.50 per copy in the U. S. A. postage free. This book collates the screw thread standards of the world, and gives them a common denominator of comparison. Over 2000 standards are listed covering 33 countries which have National Standards for screw threads. There are 108 screw thread forms illustrated, together with self-tapping screws.

"Ingenious Mathematical Problems and Methods," by L. A. Graham ($1.45) is a collection of authentic mathematical problems selected from one of the nation's most unusual puzzle columns.

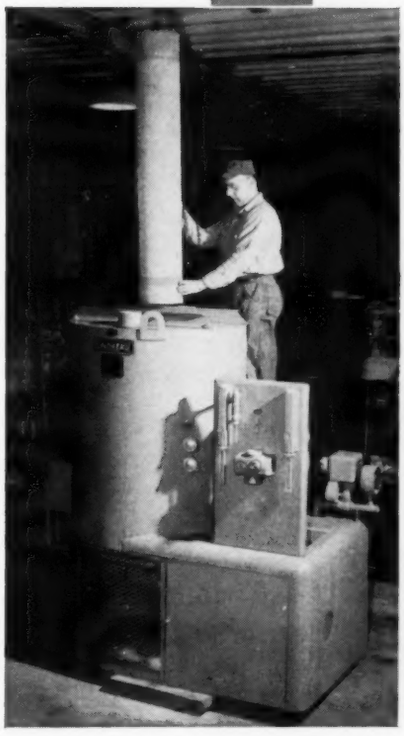
Anyone who is mathematically minded, or just a puzzle fan, will find rewarding material in this thought-provoking collection of puzzles. It may be obtained from Dover Publications, Inc., 180 Varick St., New York 14, N. Y.

1 **HOM, a new alloy developed by Duraloy metallurgists and capable of retaining high working strength at temperatures up to 2200°F, with limited application at 2300°F. The alloy is applicable for all types of castings: static, centrifugal, shell-molded.**

2 **Shell-molded castings for meeting close and rigid tolerance limits; post-casting machining or other finishing practically eliminated; low mass production costs.**

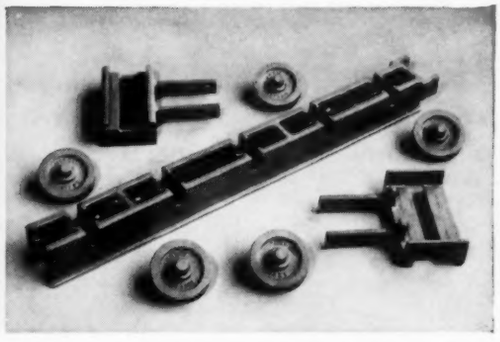
Illustrating 4 of Duraloy's Major Casting Services

If the casting used in your equipment has to meet high temperature (anything up to 2300°F) and/or corrosion, why not discuss your requirements with our metallurgical staff? Our company can call upon more than 35 years of experience in this exacting business of high alloy castings. In the meanwhile, if you would like to have a copy of our latest catalog, write or call our nearest office.



3 **Centrifugal castings which produce a denser, more uniform metal approaching forged metal strength.**

4 **Static castings which can be produced in weights ranging from a few ounces to single castings 7 tons and heavier; wide range of alloying combinations, including the new HOM referred to above.**



Note

As a point of interest, all of the castings shown here were produced for Lindberg Engineering Company, Chicago, for incorporation in heat-treating and annealing equipment sold by that company. The centrifugally cast tube for the generator, trays, and rollers for the furnace rails are cast of HOM. The rails and rail supports for the furnace are statically cast of 35-15 alloy.

ALLOY CASTING INSTITUTE ACI MEMBER

The DURALOY Company

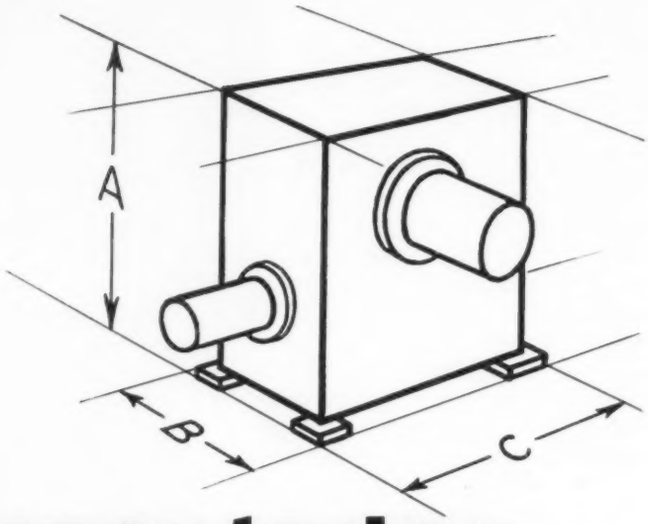
OFFICE AND PLANT: Scottdale, Pa.

EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.

CHICAGO OFFICE: 332 South Michigan Avenue

DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

Do-It-Yourself...



Let's design a speed reducer today

So you can't find a speed reducer to fit your latest brainchild without ruining the design? Doggone manufacturers all build reducers too big to fit into those few cubic feet you've got left for the reduction unit back behind the double-ended dingbat?

Revolt! Design your own! Show 'em!

By George, design it yourself and it'll fit. How? Well, you know your size limits. Draw the biggest box that'll fit the space and you've got your reducer housing specifications.

Now you need gears that will (1) transmit the needed horsepower under all operating conditions, (2) provide the ratio your machine requires and (3) fit the space that's available. You'll soon discover that there are limits to what gears can do in transmitting horsepower. The cheapest answer is parallel shaft helical gears. If they'll fit you're in clover. But they take the most room, especially when you're out of the fractional hp range. The right angle worm and gear combination is the most compact drive arrangement.

Here again you have a choice. Cylindrical worm gearing is often used, and if it'll do the job, is worth consideration. But it's not the most compact possibility. The best way to shrink gears and still carry the load is the double-enveloping worm gear design. Both worm and gear are throated and the two literally wrap around each other. This brings center distance of the two shafts closer together and you can put them inside smaller housings.

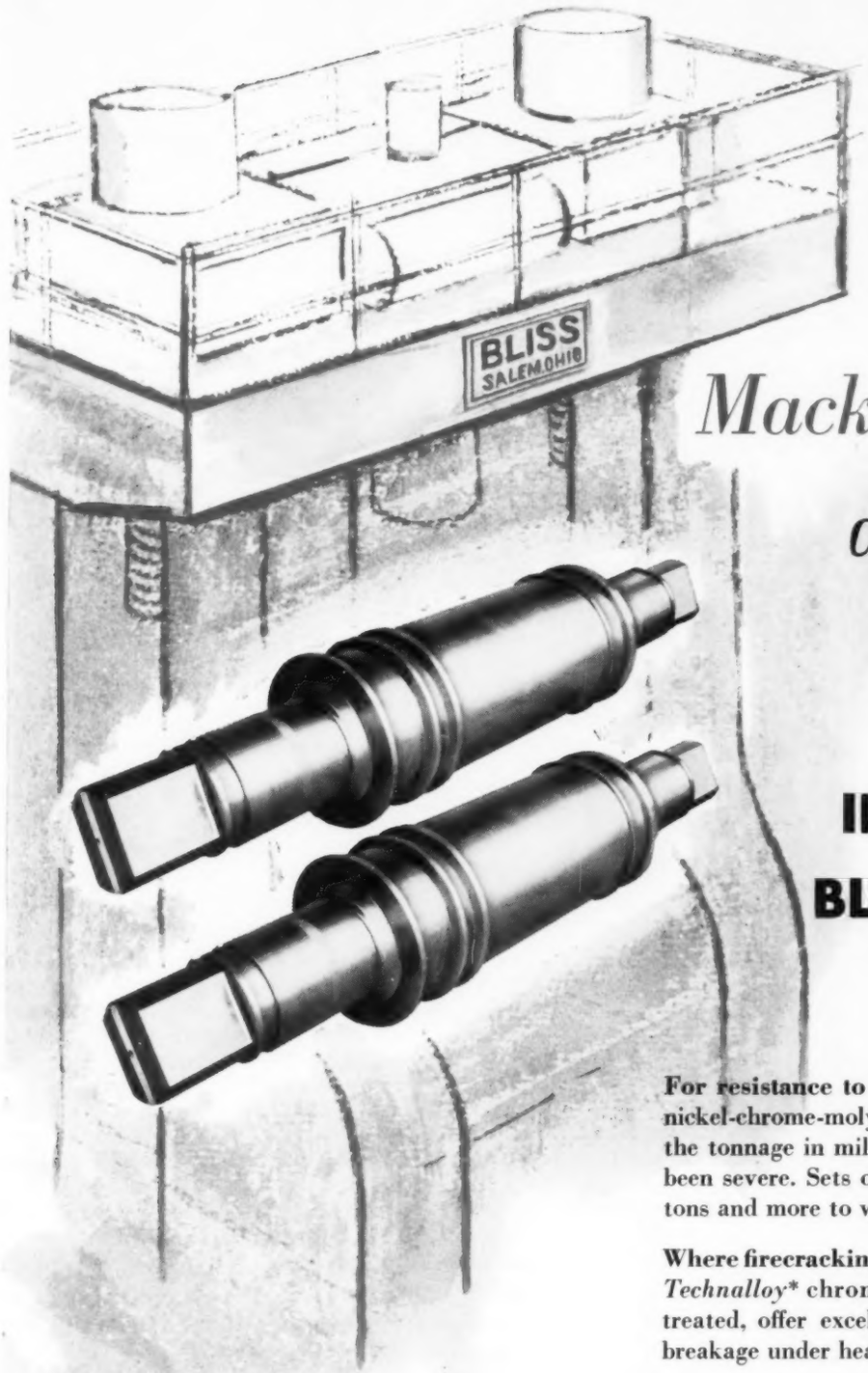
Does this reduce load capacity? No sir! You can carry the same load with center distances up to 33% smaller than those of cylindrical worm gears. Or use the same center distance and carry a greater load. Will these gears hold up in operation? Sure, if you beef up the teeth, the bearings and the housing. Use straight-sided worm and gear teeth and you'll get all the strength there you'll ever need. Use large taper roller bearings with real B-10 life. Use a reinforced, heavy wall housing that won't distort under load. Put fins on it for added cooling and increased thermal horsepower capacity to meet your needs. Now, put the whole thing together and you've got a speed reducer that's a dilly.

Designing your own speed reducer give you a headache? Looking for an easier way? There is one. Someone's already done exactly what you're talking about. You can order that compact speed reducer right off the shelf. Where?

Cone-Drive Gears, that's where!

Yes sir. They stock double-enveloping worm gear speed reducers from fractional to 665 hp. Standard ratios from 5:1 to 70:1 in about 15 increments, all interchangeable in any type housing of a given center distance. Worms over and worms under. Gear shafts vertical, too. Single- or double-extended output shafts, or shaft mounted. Over 200,000 combinations possible. Wow! Just about anything you want.

Better get Cone-Drive's new speed reducer catalog that details everything. Ask for Bulletin CD-218. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.



Mack-Hemp rolls are right for every mill

IN BLOOMING MILLS...

For resistance to side wear: Mack-Hemp *Superalloy* nickel-chrome-moly steel blooming mill rolls produce the tonnage in mills where side wear in the passes has been severe. Sets of *Superalloy* rolls have gone 900,000 tons and more to worn-out diameter!

Where firecracking is a serious problem: Mack-Hemp *Technalloy** chrome-moly steel rolls, specially heat treated, offer excellent resistance to firecracking and breakage under heavy operating conditions.

For average conditions: Heat-treated Mack-Hemp *Technisteel* carbon steel rolls provide excellent bite and good wear resistance at low initial cost.

Let us help you get exactly the right rolls for *your* blooming mills. And remember, roll service records show that *you get more tonnage from the rolls with the striped red wabblers.*

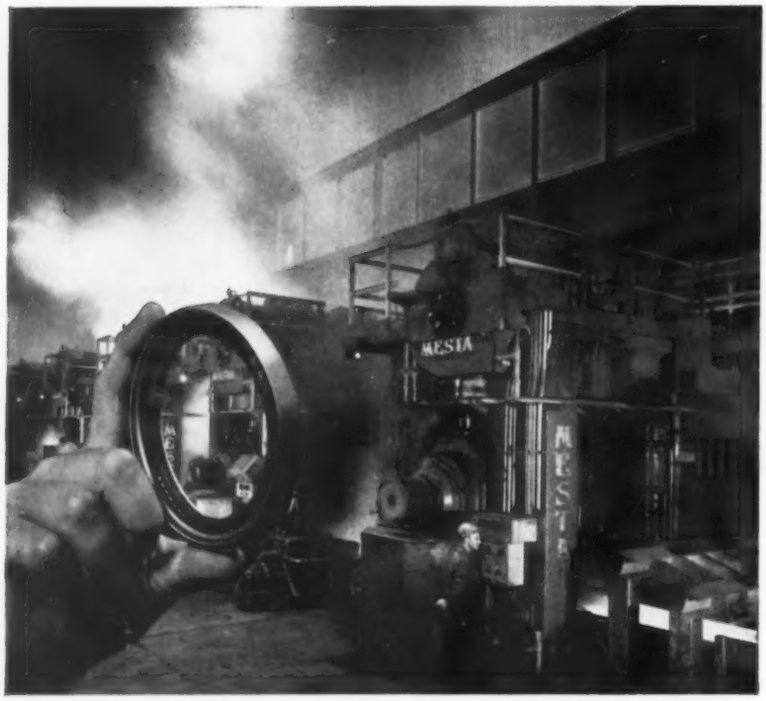
*A registered trademark—E. W. Bliss Company

MACKINTOSH-HEMPHILL DIVISION · PITTSBURGH · U.S.A. · BLISS

MACKINTOSH-HEMPHILL • DIVISION OF E. W. BLISS CO.

Pittsburgh and Midland, Pa.

ENGINEERED OIL SEALS
for Steel Mills

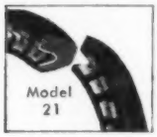


Garlock KLOZURE Oil Seals protect vital bearings from damage, add to efficiency of new Jones & Laughlin punch card-operated continuous mill at Aliquippa, Pa.

Jones & Laughlin Steel Corporation specifies Garlock KLOZURE* Oil Seals to protect important bearings on new punch card-operated mill at Aliquippa.

At dozens of vital locations on the 44″ 4-Hi Continuous Mill—approach and runout tables, vertical edgers, coilers, rotary crop shears—the Garlock KLOZURE Oil Seals perform a double duty. They stop leakage of lubrication from the bearings, prevent harmful scale, spray, dirt from getting to the bearings.

In wide use today throughout the steel industry, Garlock KLOZURE Oil Seals are available in a wide range of designs. For example, Model 142, a face-type KLOZURE, is designed to seal surfaces perpendicular to shaft . . . keeps water splash and scale out of bearings at the shoulder of mill rolls. Models 64 and 82 are applied to large shafts at normal or high speeds . . . ideal for protecting bearings on back-up and work rolls. Model 53 withstands temperatures up to 250°F at normal or high speeds . . . recommended for table rolls. Where equipment can't be dismantled easily, Models 21 or 23 Split-KLOZURES are the choice.



Like Jones & Laughlin, many of the large steel producers are enjoying the advantages of Garlock KLOZURE Oil Seals. For instance, all KLOZURES are oil and grease resistant . . . impervious to water, mild acids, alkalies . . . non-abrasive . . . withstand temperatures from −40°F to +250°F. For extreme conditions, Garlock furnishes sealing elements resistant to practically any fluid, and serviceable as high as +500°F.

Enjoy these same benefits. Talk to your local Garlock representative about high-quality KLOZURE Oil and Grease Seals. Call him at the nearest of

GARLOCK

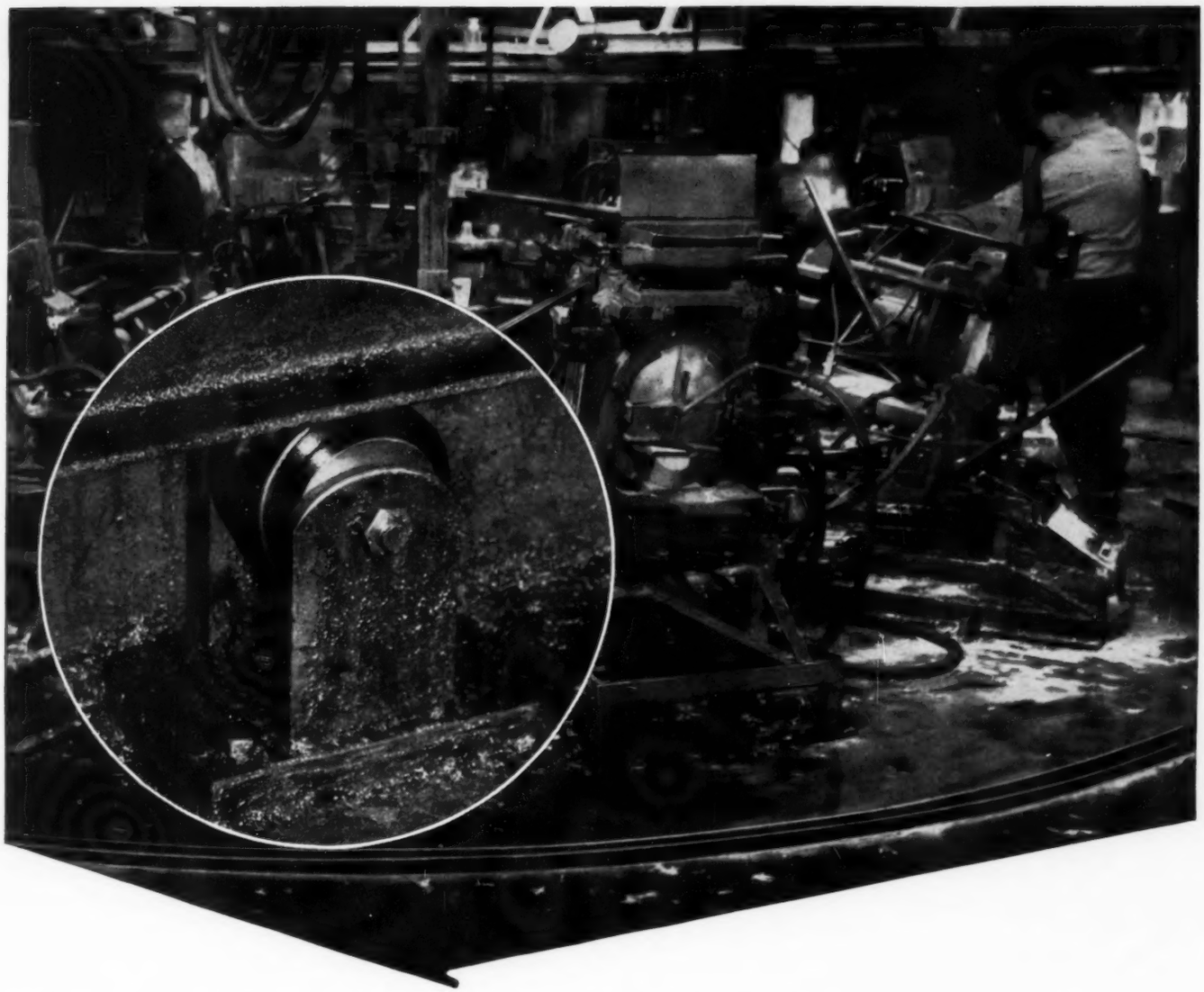
Garlock's 26 sales offices and warehouses throughout the U.S. and Canada. Or, write for KLOZURE Catalog 30. Garlock Inc., Palmyra, N. Y.

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

*Registered Trademark



Bearings, Inc. turned this turntable from a costly maintenance problem into a smooth, trouble-free operation!

Our customer, an aluminum foundry, designed and built this system for continuous and automatic pouring of permanent mold castings. The turntable is approximately 20 feet in diameter. Supporting the table, which weighs several tons, were 20 large, double-row bearings. The life of these bearings was only a few weeks and their cost, plus downtime, was becoming increasingly expensive.

Our bearing engineers were asked for a solution and, after an investigation, recommended a camroll bearing. Now, after many months of operation, all turntables in the plant are equipped with the bearings we recommended and there has not been a bearing failure in that period!

If you have a problem involving bearings, call the Bearings, Inc. branch nearest you for expert help. We are the authorized distributor for all the bearings we sell —your guarantee that the bearings we deliver will be of the latest manufacture and right for your application!

Providing bearing service

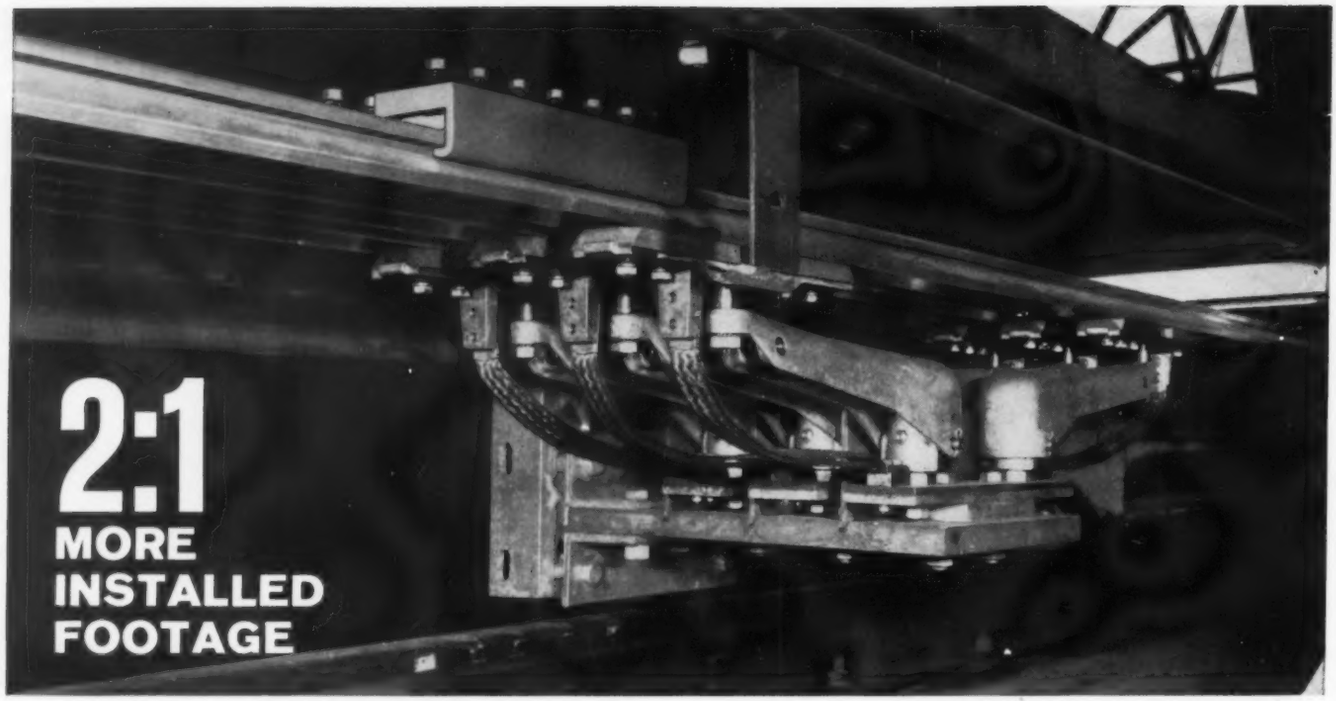
in the North → **BEARINGS, INC.**

DELAWARE: Wilmington • **ILLINOIS:** Neiman Bearings Co., E. St. Louis • **INDIANA:** Ft. Wayne • Indianapolis • Muncie • Terre Haute • **MARYLAND:** Baltimore • **MISSOURI:** Neiman Bearings Co., St. Louis • **NEW JERSEY:** Camden • Newark • **NEW YORK:** Balanrol Corp., Buffalo • Niagara Falls • **OHIO:** Akron • Canton • Cincinnati • Cleveland • Columbus • Dayton • Elyria • Hamilton • Lima • Lockland • Mansfield • Painesville • Toledo • Youngstown • Zanesville • **PENNSYLVANIA:** Erie • Johnstown • Philadelphia • Pittsburgh • York • **WEST VIRGINIA:** Charleston • Huntington • Parkersburg • Wheeling

and

in the South → **DIXIE BEARINGS, INC.**

ARKANSAS: Little Rock • **FLORIDA:** Jacksonville • **GEORGIA:** Atlanta • **KENTUCKY:** Louisville • **LOUISIANA:** Baton Rouge New Orleans • **N. CAROLINA:** Charlotte • Greensboro • **S. CAROLINA:** Greenville • **TENNESSEE:** Chattanooga • Kingsport • Knoxville Memphis • Nashville • **VIRGINIA:** Norfolk • Richmond • Roanoke



Inverted V-Type conductor extrusion gives protected contact surface. Collector design provides for low current density—minimizes arcing and heating.

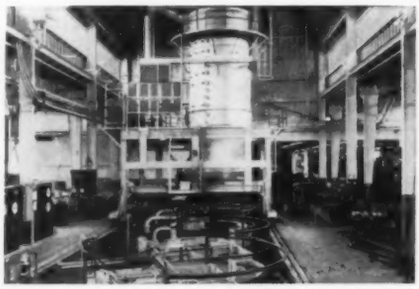
SUPERIORITY OF DELTA-STAR INTEGRATED DESIGN PROVEN BY OVERWHELMING CUSTOMER ACCEPTANCE

Operating in all kinds of atmospheres, more footage of *fully engineered* Delta-Star Integrated Aluminum Crane Conductor-Collectors are installed than all competitive makes combined.

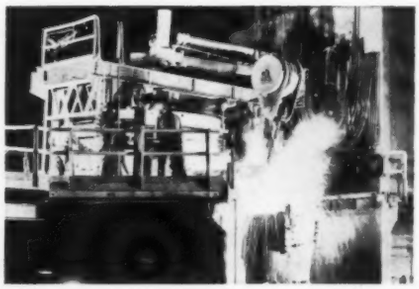
Delta-Star aluminum systems are easily installed, space-saving, and are corrosion-resistant. They eliminate the need for copper boosters, and reduce voltage drop. In the high ambient and corrosive conditions typical of blast furnaces, ship yards and other industrial applications, Delta-Star systems have provided efficient performance with low maintenance.

Integrated Aluminum Systems are available with continuous ratings of 500, 1000, 2000, 3000, and 6000 amps. For special applications, bronze and copper systems also are available with ratings from 450 to 2000 amps. For more complete information on the finest *fully engineered* crane conductor systems available, write to *Delta-Star Electric Division, H. K. Porter Company, Inc., 2437 W. Fulton Street, Chicago 12, Illinois.*

Ship yard installation defies extremely corrosive salt air.



Traveling gantry type furnace at a mid-western steel treating company.



Blast furnace installations withstand high ambient temperatures.

DELTA-STAR ELECTRIC DIVISION PORTER **H. K. PORTER COMPANY, INC.**

PORTER SERVES INDUSTRY with steel, rubber and friction products, asbestos textiles, high voltage electrical equipment, electrical wire and cable, wiring systems, motors, fans, blowers, specialty alloys, paints, refractories, tools, forgings and pipe fittings, roll formings and stampings, wire rope and strand.

TRANTINYL GUIDES
THE STEEL INDUSTRY

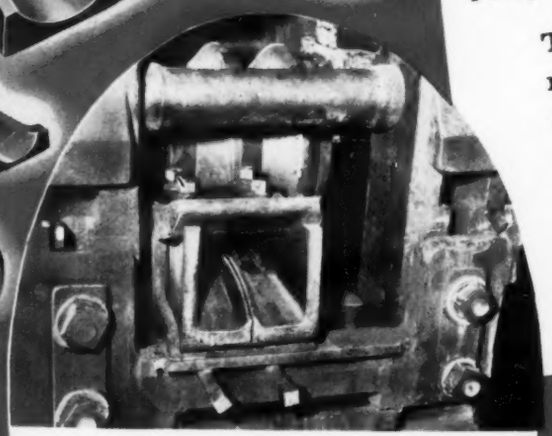
Steel Producers amazed at HIGH TONNAGE rolled with TRANTINYL GUIDES

Entry Guides

Delivery Guides

Two pair of angle guides, still in serviceable condition after long usage

These entry and delivery guides on 12" mill were photographed in a midwest steel plant after rolling unusually high tonnage. Guides showed no noticeable signs of wear and proved again the outstanding durability of "TRANTINYL." If you have not yet tested "Trantinyl" guides to your own satisfaction, why not try them now.



12" Mill showing Entry Guides

"Trantinyl" Guides and Rollers hold exceptionally high tonnage performance records, in serving leading steel mills for a quarter-century. Rolling more than 100,000 tons over a single pair of guides has been recorded.

Guides for Rolling Mills • Tube Mills
Straightening Machine Guides
Heat-Resisting "Trantinyl" Cast-to-Shape

Youngstown Alloy Casting Corporation
Youngstown, Ohio

Sole Licensee to cast "TRANTINYL" for the Midwest, West and South: WAUNAKEE ALLOY CASTING CORP., Waunakee, Wis.

HIGH-PRESSURE JETS BLAST DEPOSIT-PACKED BUNDLES CLEAN AS NEW

The high-pressure jet unit below is blasting solidly-caked deposits from a heat exchange bundle . . . removing substantially all traces of deposits throughout the bundle, without cutting it apart!

Nation-wide Dow Industrial Service developed this automatic unit to remove scale, coke and asphalt deposits without metal erosion or wall thinning. This is just one of many advanced tools and techniques developed by Dow Industrial Service to clean equipment of every kind... boilers, pipelines, chemical process equipment, towers, scrubbers.

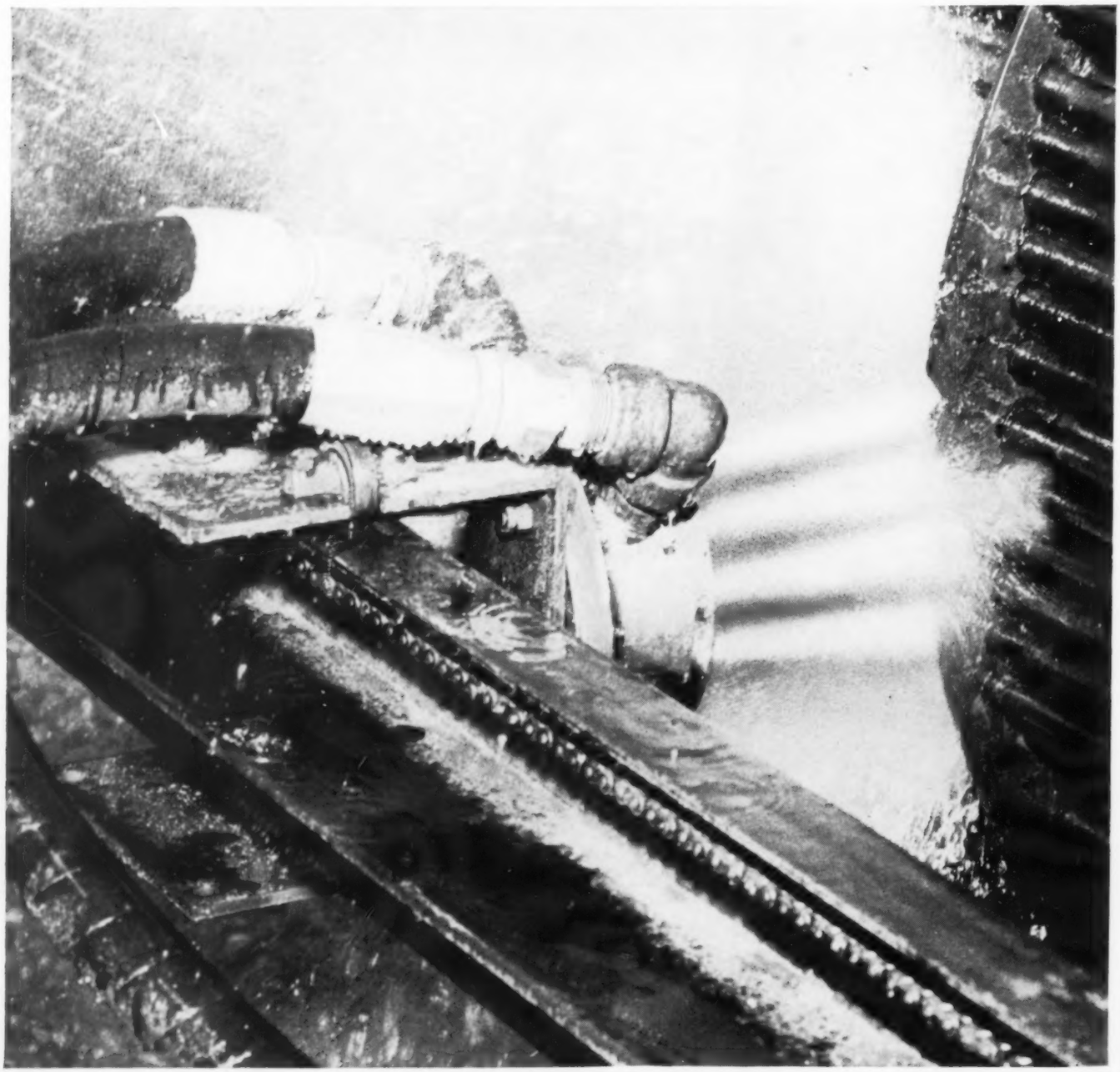
D. I. S. engineers first analyze your problem, then pick the most effective cleaning method . . . whether chemicals, steam, jet, foam, or other means. D. I. S. tailors the technique to give you most value per dollar.

In addition, D. I. S. offers complete consulting laboratory service for water treatment and waste processing problems, backed by the technical resources of The Dow Chemical Company.

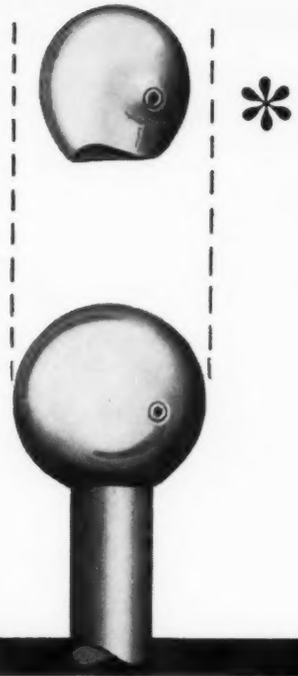
D. I. S. is a nation-wide industrial service . . . and offers "total" cleaning. For cleaning equipment of *any* kind, *anywhere*, call D. I. S. We'll be glad to show you how to set up a year 'round cleaning program to *keep* equipment operating at top efficiency. Write or call DOW INDUSTRIAL SERVICE, 20575 Center Ridge Road, Cleveland 16, Ohio.

DOW

DOW INDUSTRIAL SERVICE • Division of The Dow Chemical Company



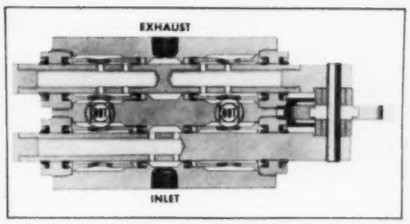
Automatic jet unit removes bundle deposits, without dismantling.



after 17 years... replacement parts ***one handle ball!***

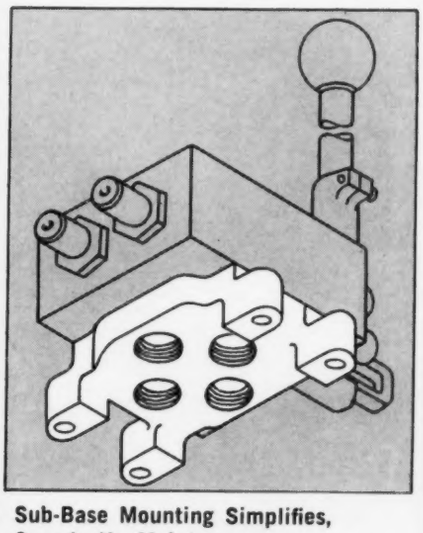
Human hands wore this metal handle ball to a fraction of its original size before the customer returned the valve to us for reconditioning. This high pressure hydraulic valve performed faithfully for nearly two decades with only such minor maintenance as replacement of "U" packing. We replaced the handle ball, repacked it, cleaned it up, and sent it back. This kind of trouble-free service is typical of Hunt hydraulic valves.

¾" MS-551-N4



The Higher the Pressure The Tighter the Seal

Cross-section view shows Hunt system of "U" packing as opposed to "metal to metal". "U" packing provides zero leakage on water hydraulic service.



Sub-Base Mounting Simplifies, Speeds Up Maintenance

New sub-base mounting is now available on all Hunt hydraulic valves. Easy, quick replacement for maintenance with no disconnecting of pipes.

HUNT

HUNT VALVE COMPANY DIVISION OF IBEC SALEM, OHIO

Quick-As-Wink AIR & HYDRAULIC CONTROL VALVES

BIG—BUT TAKEN IN STRIDE BY B-L-H's FABRICATING TEAM

Fabricating jobs like the nuclear reactor being installed for the AEC at Hallam, Nebr., are no strangers to B-L-H. We have handled such tasks many times.

To get an idea of what's involved, note these facts about the Hallam reactor:

Reactor vessel

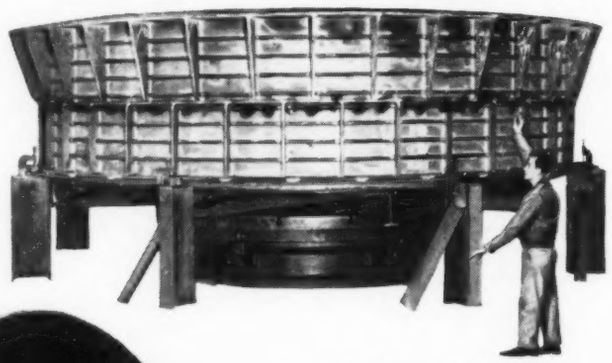
- 19 ft. in diameter, 33 ft. high, welded of Type 304 stainless steel
- Metal thickness range from ¾ to 2 in.
- All material subject to ultrasonic inspection; all welds inspected radiographically, also with dye penetrant and helium leak detection equipment

Reactor containment vessel

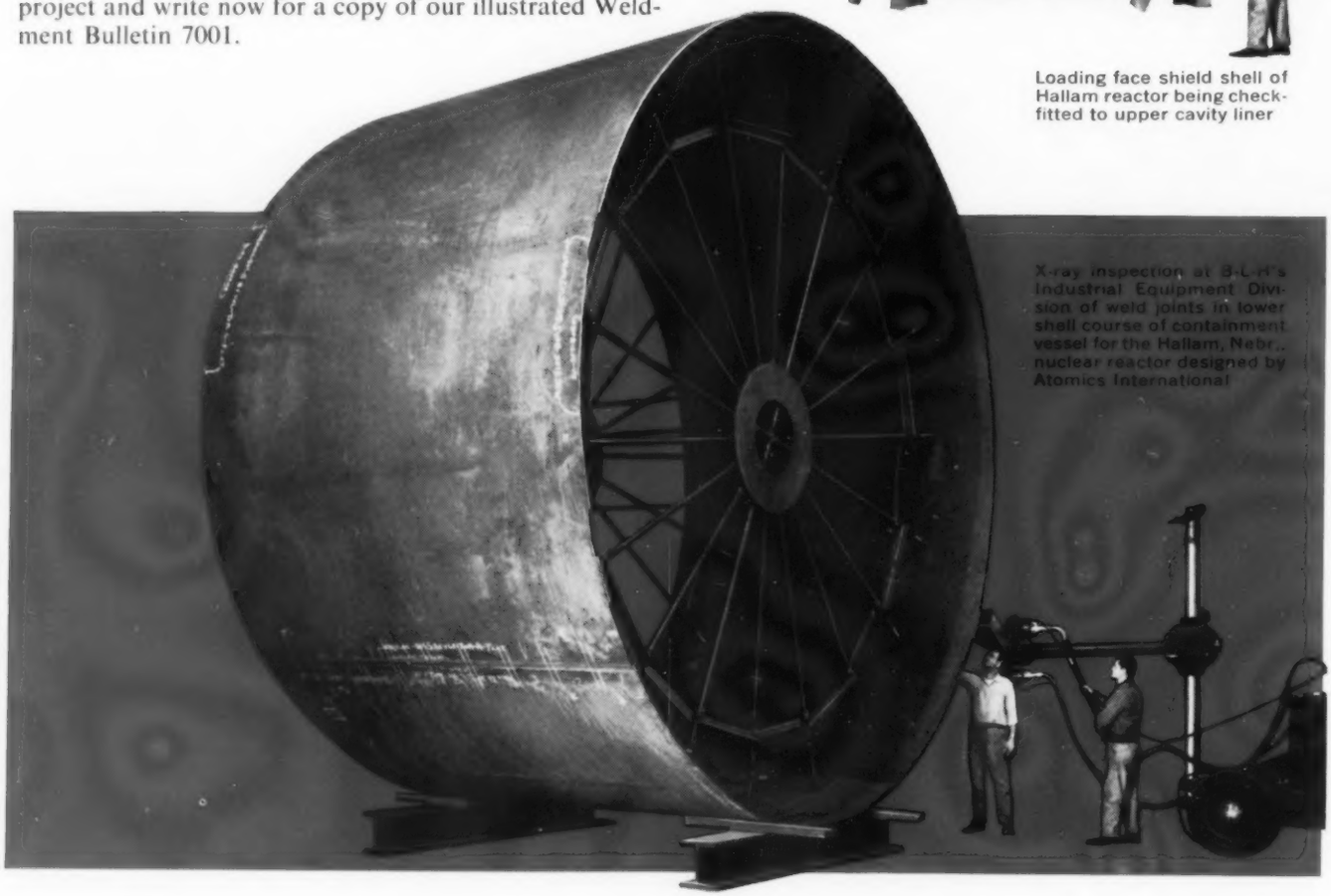
- 21 ft. in diameter, 36 ft. high
- Bottom head fabricated of carbon-silicon steel, main barrel section of chromium molybdenum steel
- All welds radiographed, bottom head section stress relieved

Keep in mind, too, the fact that for parts as large as these —and with the limited amount of machining—the tolerances call for highest accuracy in fabrication.

Handling big fabricating jobs economically and efficiently is our stock in trade. So take advantage of our exceptional experience and competence. Consult us about your next project and write now for a copy of our illustrated Weldment Bulletin 7001.



Loading face shield shell of Hallam reactor being check-fitted to upper cavity liner



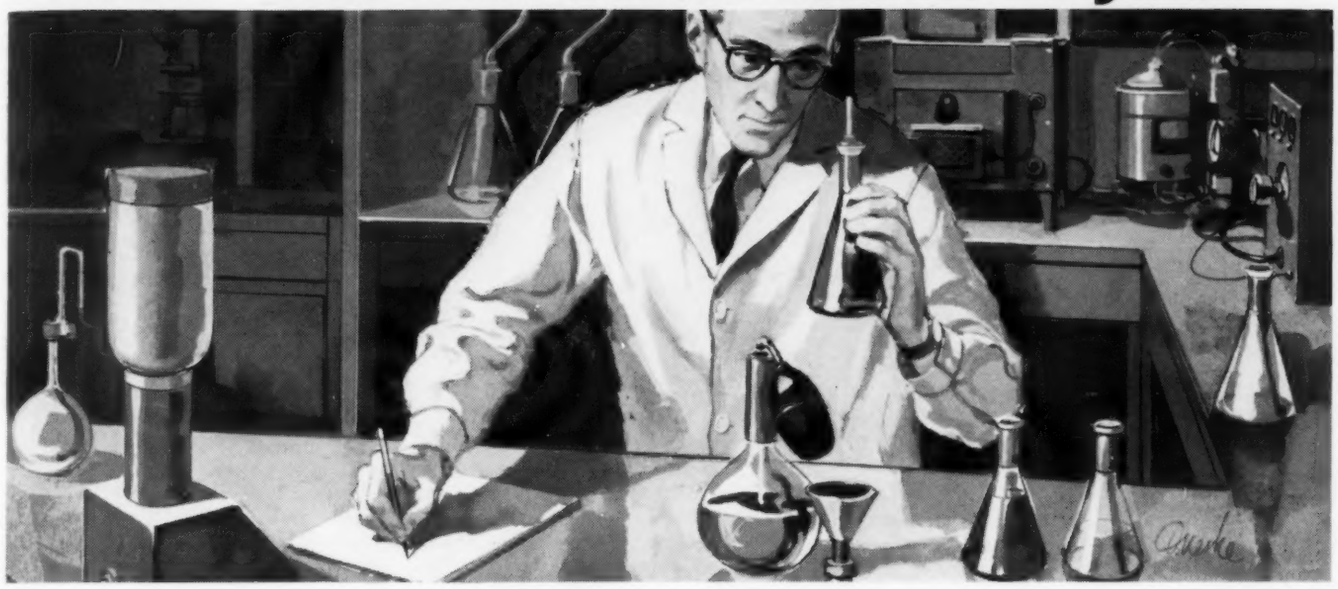
X-ray inspection at B-L-H's Industrial Equipment Division of weld joints in lower shell course of containment vessel for the Hallam, Nebr., nuclear reactor designed by Atomics International

BALDWIN · LIMA · HAMILTON

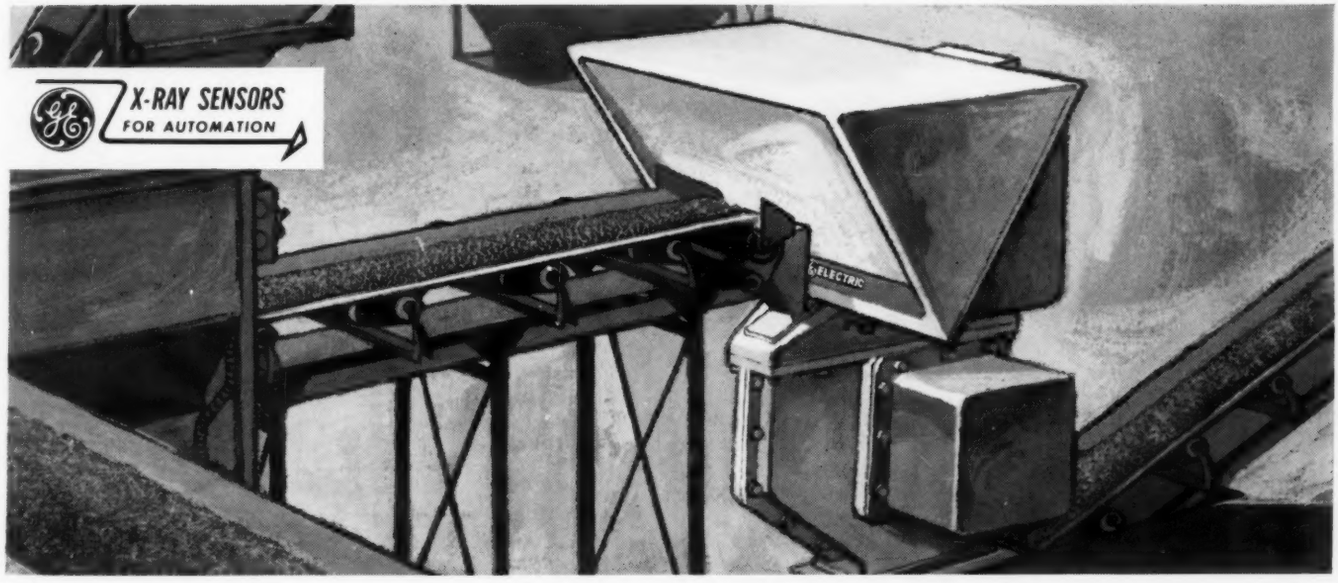
Industrial Equipment Division · Philadelphia 42, Pa.

BALDWIN · BLH · LIMA-HAMILTON

"XEG" moves materials analysis



out of the lab...



onto the line!

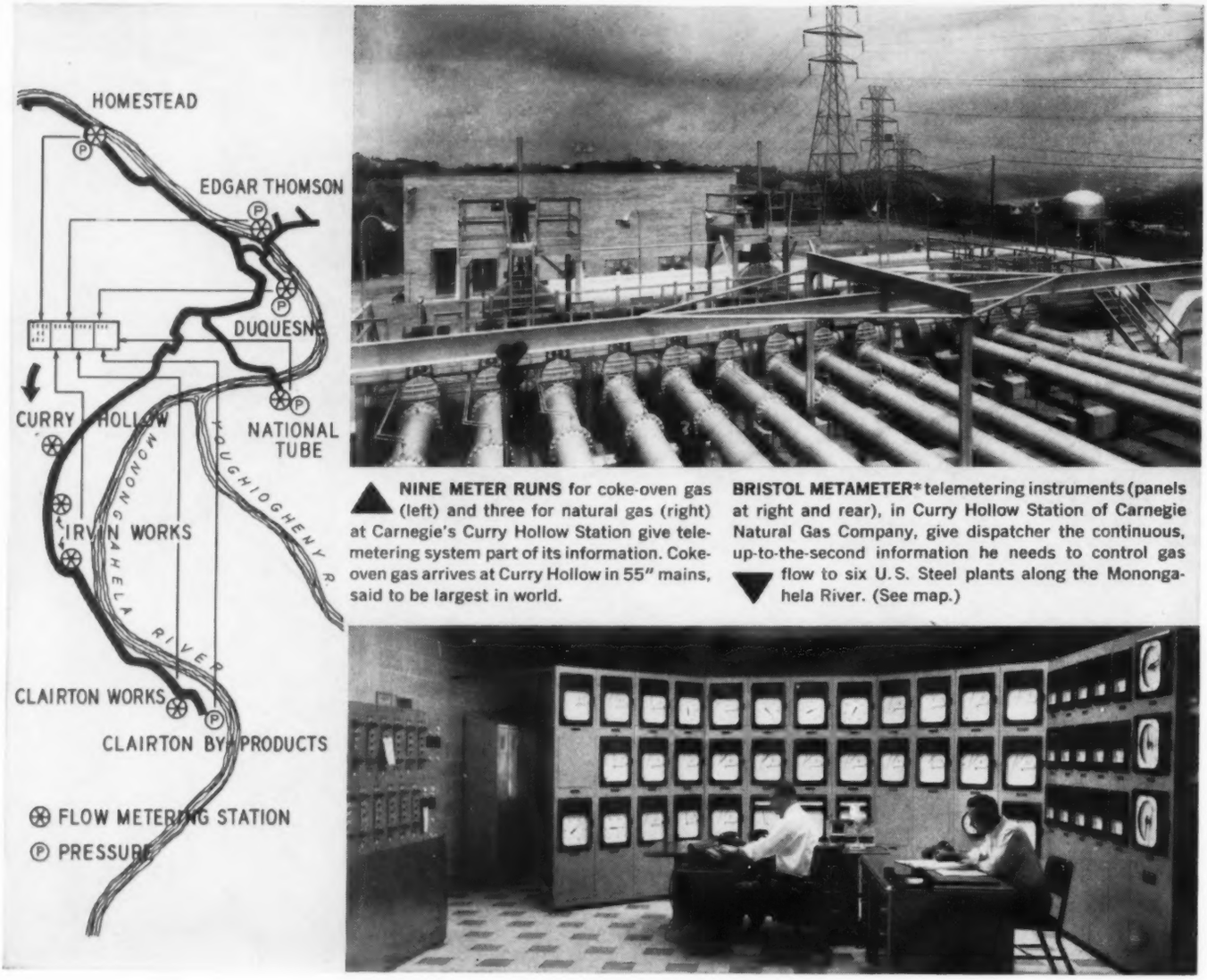
General Electric's revolutionary X-Ray Emission Gage offers what amounts to an "on-line" *laboratory* for quality control. XEG performs continuous analysis of solids, liquids, liquid mixtures, slurries, powders, sheets, rods, wire or similar materials *during actual production.* It monitors up to 5 selected elements . . . maintains *moment-by-moment* surveillance, sensing both presence and quantity.

Expressly intended for the production line, XEG also is suited to individual sample analysis. Operation requires no scientifically trained personnel . . . facts on composition are delivered automatically, instantly, for rapid-fire feedback to process control.

You'll find uses of XEG as unlimited as the imagination! Discover how you can take full advantage of this remarkable innovation — get complete information now from your local G-E representative. Or write to X-Ray Department, General Electric Company, Milwaukee 1, Wisconsin, Room IS-104.

Progress Is Our Most Important Product

GENERAL ELECTRIC



▲ **NINE METER RUNS** for coke-oven gas (left) and three for natural gas (right) at Carnegie's Curry Hollow Station give telemetering system part of its information. Coke-oven gas arrives at Curry Hollow in 55" mains, said to be largest in world.

BRISTOL METAMETER* telemetering instruments (panels at right and rear), in Curry Hollow Station of Carnegie Natural Gas Company, give dispatcher the continuous, up-to-the-second information he needs to control gas flow to six U.S. Steel plants along the Monongahela River. (See map.) ▼

GAS FOR THE MILLS OF U.S. STEEL

...telemetered by Bristol

Supplying the U. S. Steel plants along the Monongahela River with sufficient fuel to carry on operations is the primary mission of Carnegie Natural Gas Company, Pittsburgh, Pa., a subsidiary of the United States Steel Corporation.

Bristol Metameter* Telemetering gives the gas dispatcher, at the Curry Hollow Station, all the information he needs for efficient, economical pipeline operation.

At Curry Hollow (see map), Carnegie mixes natural gas from company-owned fields to supplement artificial gas produced at the Clairton By-Product Coke Works. Some of the coke-oven gas is used at the Clairton and Irvin Steel works. The mixed gas is supplied to the remaining plants.

The Bristol telemetering system measures individual gas flows and pressures in every main. Individual flows are totalized at Homestead, Irvin, Duquesne, and Edgar Thomson Works and transmitted to the dispatcher's office in Curry Hollow. At Curry Hollow, the Irvin and Clairton Steel Works flows are again totalized with the flow in the 55-inch mains from Clairton to secure the total coke-oven gas output.

Why not find out how Bristol telemetering can improve *your* plant or operations? Bristol Metameter systems are in service by the thousands, today, on natural gas pipelines, oil pipelines, gas distribution systems, electrical transmission networks, steel plants, water distribution systems and in industrial plants. Highly-trained Bristol engineers, drawing upon Bristol's more than 45 years' experience in industrial telemetering, are available to work with you in planning, design, and installation.

For details, write for bulletin M1710. The Bristol Company, 123 Bristol Road, Waterbury 20, Conn. *T.M. Reg. U.S. Pat. Off.

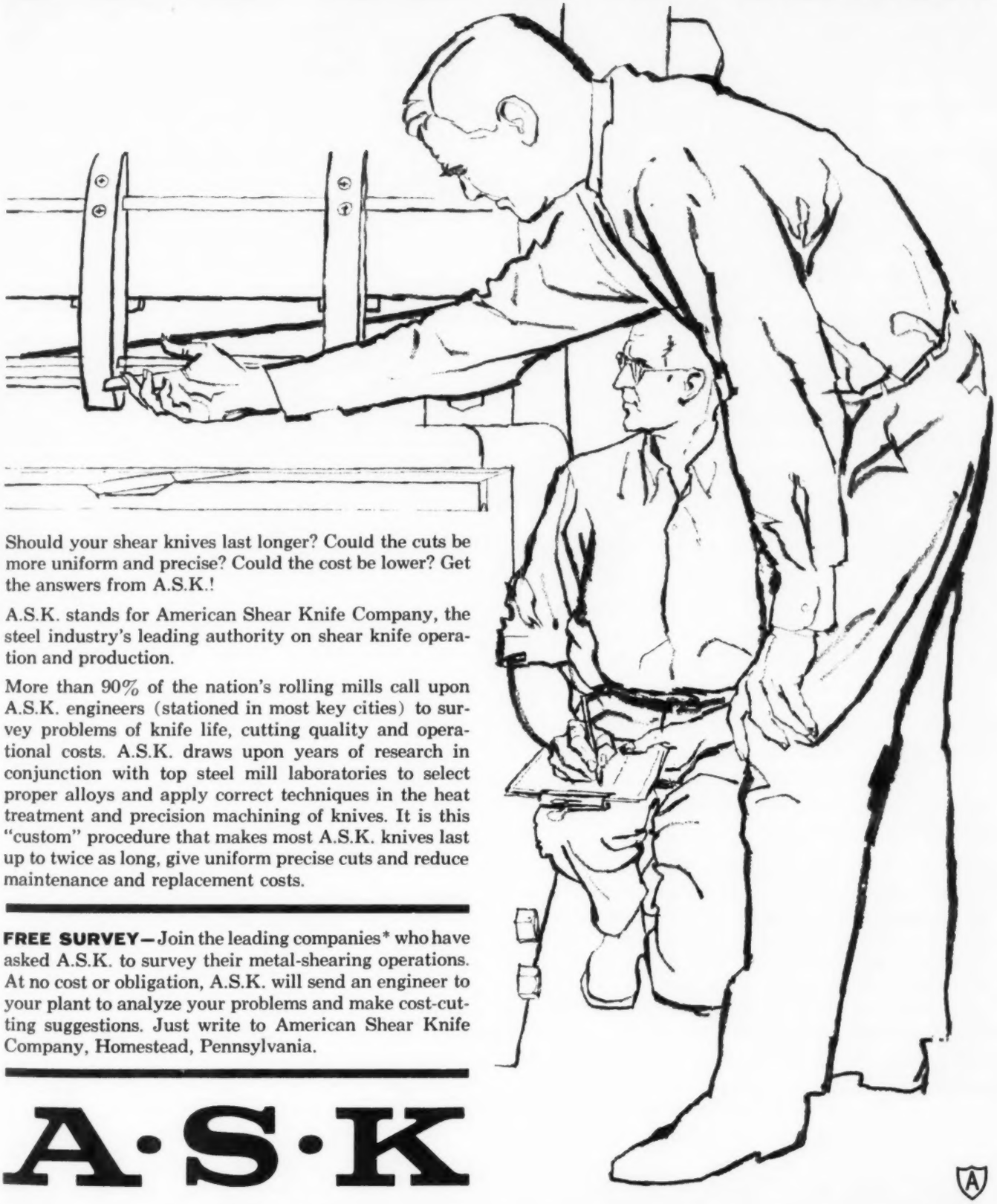
0.17

BRISTOL... for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

Can you get more wear from your shear knives?

A·S·K for the answer!



Should your shear knives last longer? Could the cuts be more uniform and precise? Could the cost be lower? Get the answers from A.S.K.!

A.S.K. stands for American Shear Knife Company, the steel industry's leading authority on shear knife operation and production.

More than 90% of the nation's rolling mills call upon A.S.K. engineers (stationed in most key cities) to survey problems of knife life, cutting quality and operational costs. A.S.K. draws upon years of research in conjunction with top steel mill laboratories to select proper alloys and apply correct techniques in the heat treatment and precision machining of knives. It is this "custom" procedure that makes most A.S.K. knives last up to twice as long, give uniform precise cuts and reduce maintenance and replacement costs.

FREE SURVEY—Join the leading companies* who have asked A.S.K. to survey their metal-shearing operations. At no cost or obligation, A.S.K. will send an engineer to your plant to analyze your problems and make cost-cutting suggestions. Just write to American Shear Knife Company, Homestead, Pennsylvania.

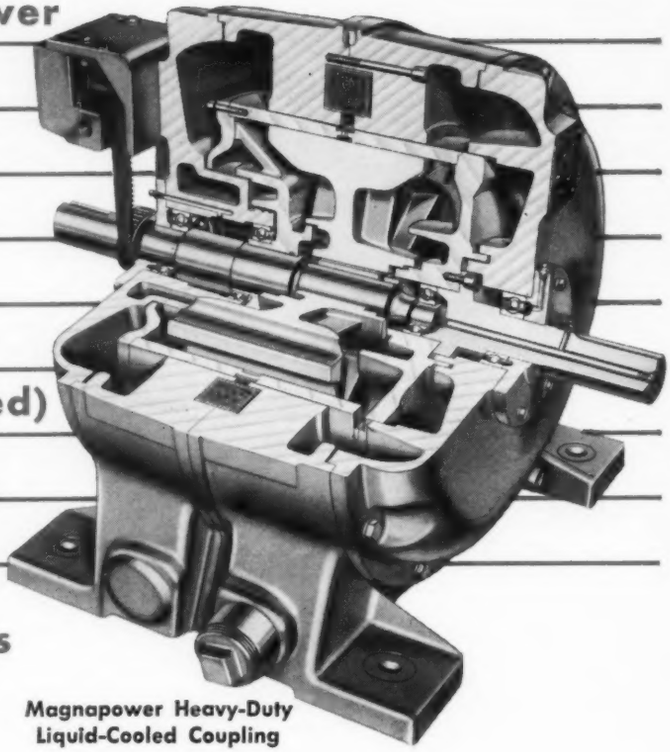
A·S·K

AMERICAN SHEAR KNIFE

**names supplied on request*

10 good reasons for choosing Dynamatic Eddy-Current Speed Control Equipment

1 Adjustable speed from AC power
2 Accurate speed control
3 Wide speed range
4 Rapid response
5 Low power loss
6 Simplified construction
7 Remote control (when desired)
8 Quiet, efficient operation
9 Low maintenance cost
10 No commutators, rings, brushes, or rotating coils



Magnapower Heavy-Duty Liquid-Cooled Coupling

Using standard alternating current as a power source, Dynamatic Eddy-Current Couplings and Drives are the answer to practically all stepless adjustable speed requirements.

A wide range of standard and special control features may be obtained from electronic or transistorized magnetic amplifier control systems. The addition of an eddy-current brake to standard couplings or drives provides smooth, cushioned stops and controlled deceleration.

Dynamatic Eddy-Current Equipment is available in sizes from ¼ hp Ajusto-Spede Drives to heavy-duty Magnapower Couplings rated up to 20,000 hp—and larger.

Place your speed control problems in the hands of experts. Our representatives, located in all principal cities, are fully qualified to discuss your speed control problems and suggest Dynamatic Equipment that will do the best job for you. Call Dynamatic today—there is no obligation.

EATON

DYNAMATIC®

ORIGINATOR AND LEADING PRODUCER OF EDDY-CURRENT SPEED CONTROL EQUIPMENT

May we Send You Illustrated Literature Describing Dynamatic Eddy-Current Equipment

EATON DYNAMATIC DIVISION
MANUFACTURING COMPANY
3122 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

PUTTING IT ON THIS LINE PAYS OFF

- **IN LOWER PRODUCTION COST**
- **IN HIGHER RATE OF PRODUCTION**
- **IN IMPROVED QUALITY STANDARDS**

DREVER WIDE PLATE HEAT TREATING LINE

One man in the control booth (just beyond the high framing of the pressure quench), by "pushbutton" control and television monitoring, operates this 550′ long Drever Wide Plate Heat Treating Line. It processes alloy or carbon steel plate up to 172″ wide by 3″ thick and 600″ long through hardening furnace, pressure quench and tempering furnace. Close control of each stage assures high, uniform quality—and the 21½ ton per hour capacity provides high, economical production.

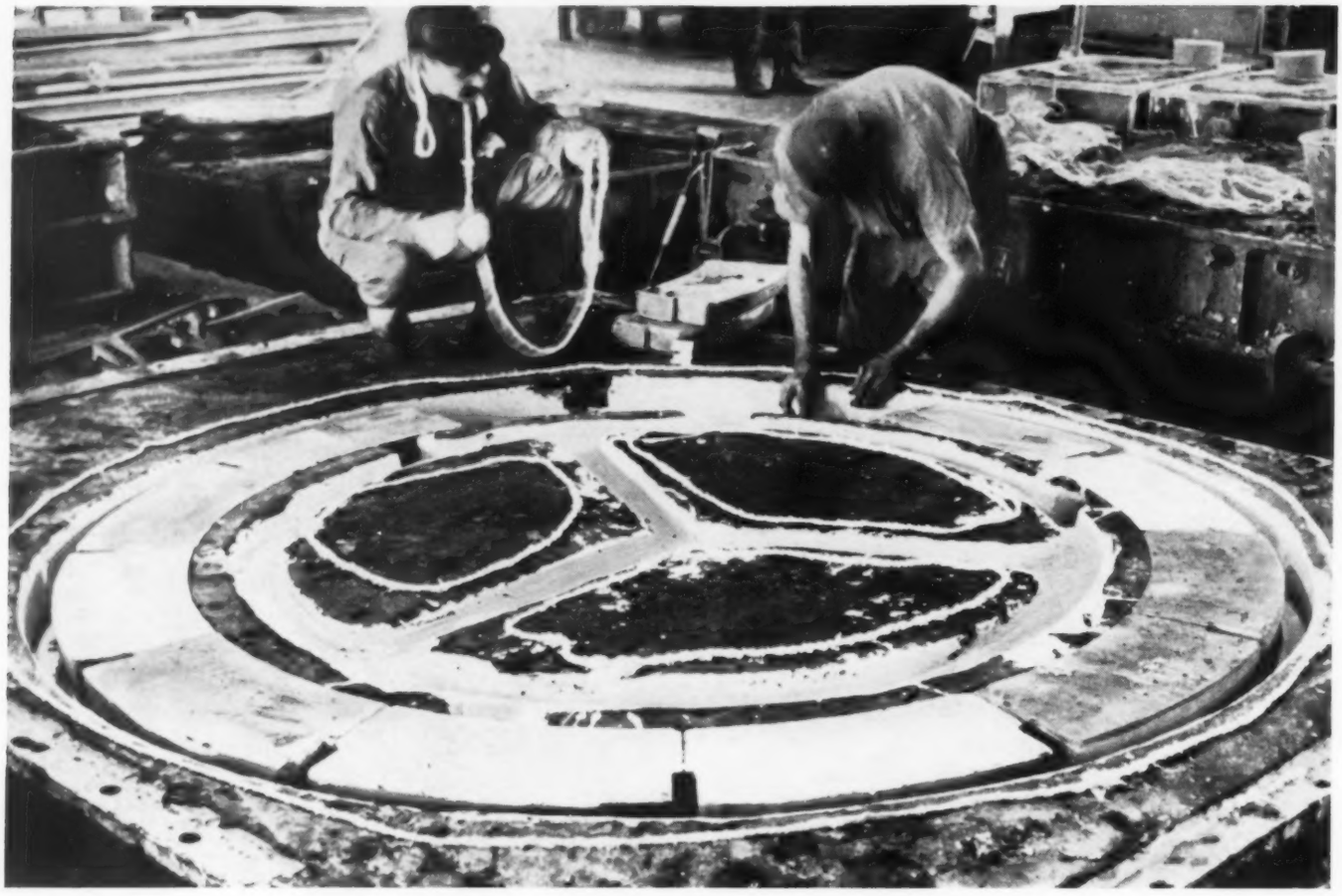
DREVER ENGINEERING FOR YOU

Designing and installing a line like this involves a wide range of knowledge. This knowledge can be used to provide the answer to your particular furnace or heat treating requirements in equipment as large as this—or much, much smaller. Write or phone us. Drever Company, Bethayres, Pa. Phone WI 7-3400

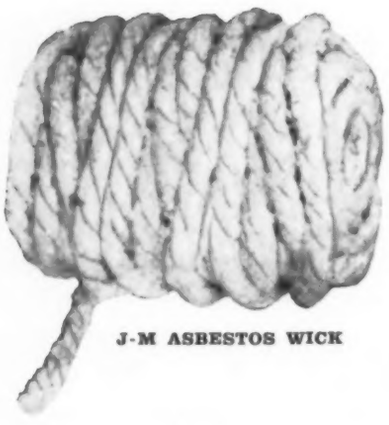
DREVER INDUSTRIAL FURNACES

ENGINEERED TO YOUR PARTICULAR REQUIREMENTS

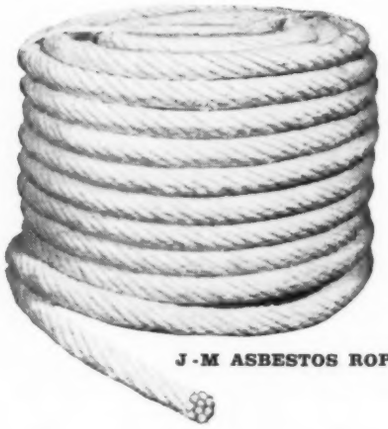
ENGINEERING AND MANUFACTURING FACILITIES AROUND THE WORLD THROUGH ASSOCIATES IN FRANCE, GREAT BRITAIN, GERMANY, ITALY AND JAPAN



Two quality materials with hundreds of caulking and sealing uses!



J-M ASBESTOS WICK



J-M ASBESTOS ROPE

Whether you are sealing a sand mould or need an emergency caulking, you can rely on these versatile materials. They are easily handled . . . are soft and compressible, conforming readily to surface irregularities for secure sealing even on worn moulds or bases. Made of 98/99% pure asbestos, they withstand high temperatures.

Their many other all-'round plant uses make Asbestos Wick and Rope virtually indispensable throughout industry. For example:

USE ASBESTOS WICK (Style No. 4202) to pack small valve stems on exhaust, vapor or low pressure lines . . . caulking retorts, ovens, boiler walls . . . as gasketing between cope and drag on foundry flasks . . . for emergency steam line repairs.

USE ASBESTOS ROPE (Style No. 4200) to wrap around hot lines . . . fill spaces in oven construction . . . blast furnace connection...for caulking larger apertures where dry heat is a factor.

These are only a few of the varied uses you will discover for Asbestos Wick and Asbestos Rope. They are supplied in a range of sizes up to two inches. Because of high purity, these J-M styles will handle much higher temperatures than commercial grade wick and rope. For further information, see your J-M Distributor. Or write to Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ont. Offices throughout the world. Cable address: Johnmanvil.

JOHNS-MANVILLE

SPECIAL CYLINDERS

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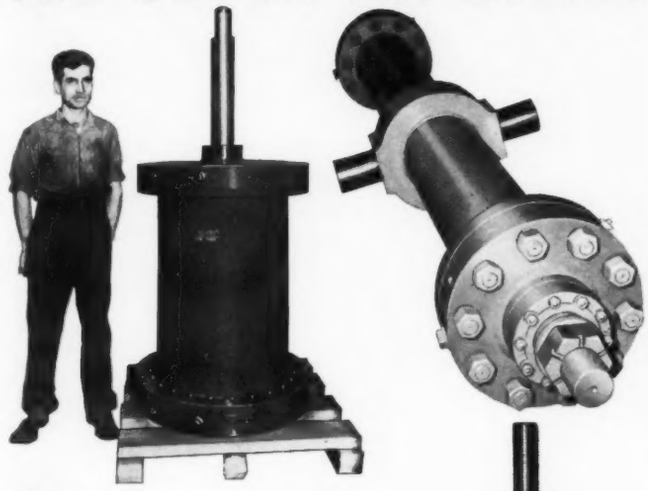

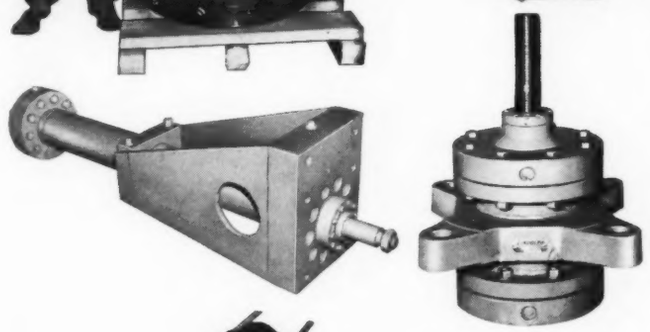

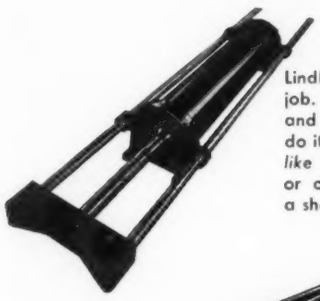

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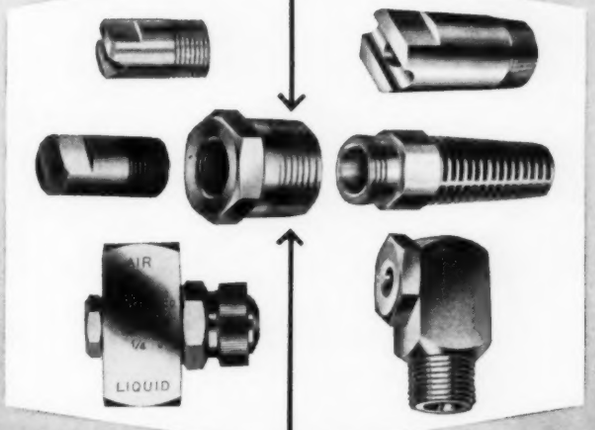

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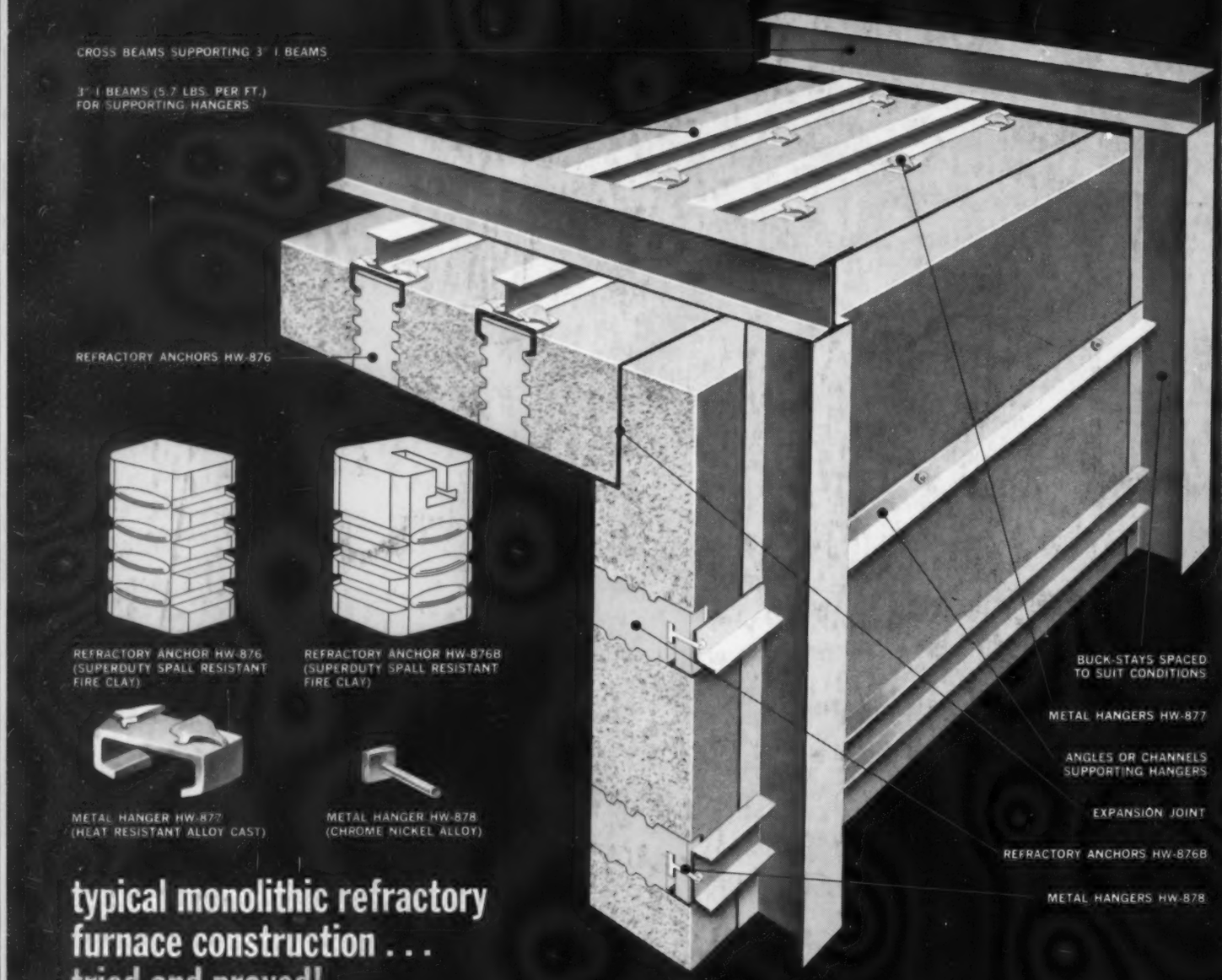
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